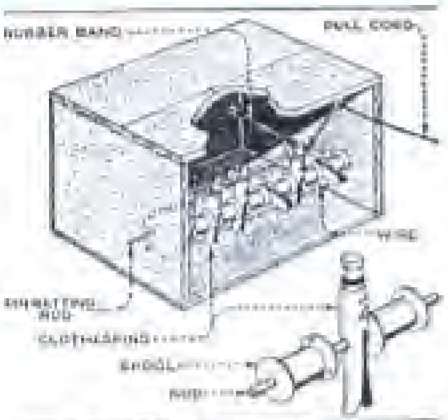
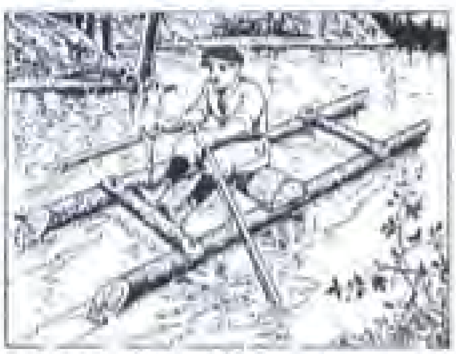
THE SURVIVOR

Volume 2

By Kurt Saxon



A Pistol Butt for Indoor Use, by Means of Which the Young Marksman can Improve His "Shot" with Harmless Weapons Such as Marbles, Peas and Darts



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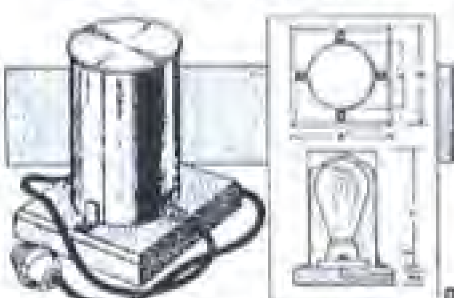
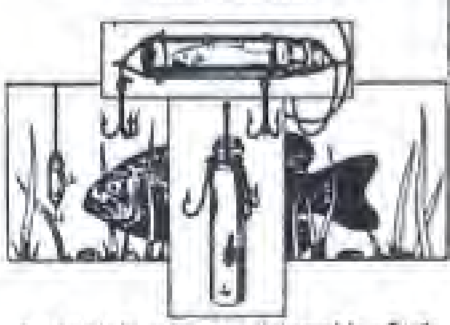


A Handy Electric Stove can be Made at an Outlay of 90 Cents

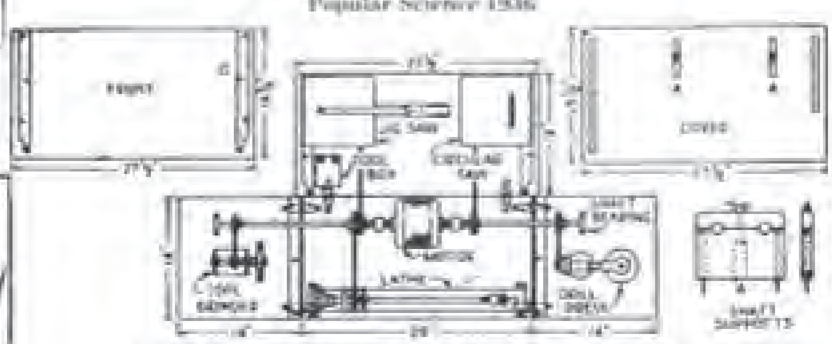


The Bait is Kept Alive and Unharmed in a Bottle Surrounded with Hooks

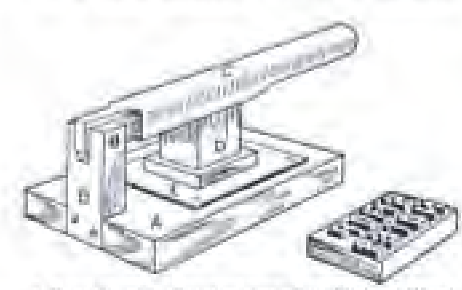
Popular Science 1936

JUST A FEW OF THE ARTICLES IN VOLUME 2

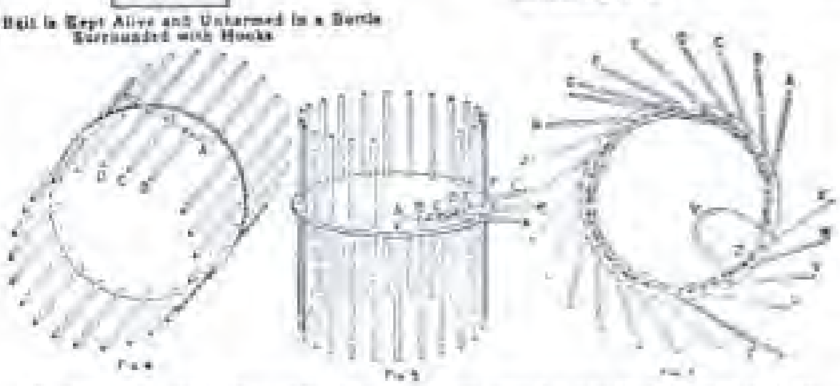
- Complete Course in Hydroponics
- Portable Shop
- Survival Kits
- Tie a Hangman's Noose
- Radio Control
- Reed Furniture
- Survival Shelter
- Experiments With The Microphone Transmitter Button
- Utility Press
- Reflex Building
- Survival Fishing
- Home-Made Toys
- Science From Chambers Encyclopedia, 1891
- Electroplating Non-Metallic Objects
- Silk Screen Printing
- Dick's Encyclopedia of Formulas and Processes, 1872
- Intruder Detector
- Leather Working
- Animal Traps
- Silk-Screen Printing
- Plus Much, Much More



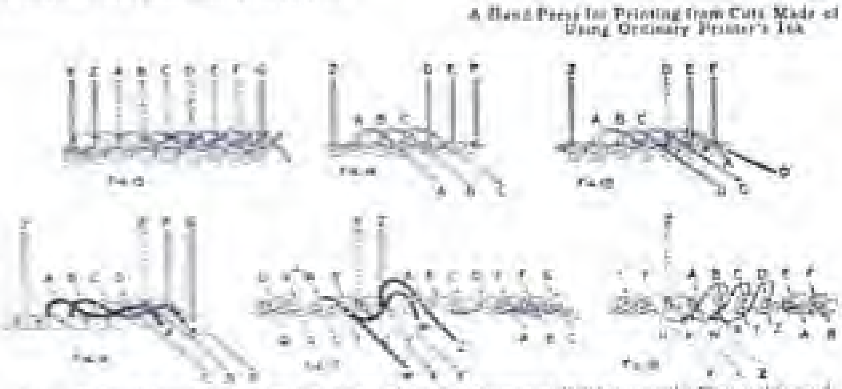
The front [illegible] of the box are removed and the remaining parts are [illegible] the drawing above



A Hand Press for Printing from Cuts Made of Wood, Using Ordinary Printer's Ink



The Bottom is Cut from a Piece of Wood to Give Strength and to Avoid the Most Difficult Part of the Weaving; the Reeds are Attached to the Bottom and Their Lower Ends Bent as Shown



A Simple Braid Border Built for the Top; Also a Method of Forming a Roll between the First and Second Spokes Where Only Three Stakes are Turned Down Before the Throwing Across Process Begins

THE SURVIVOR
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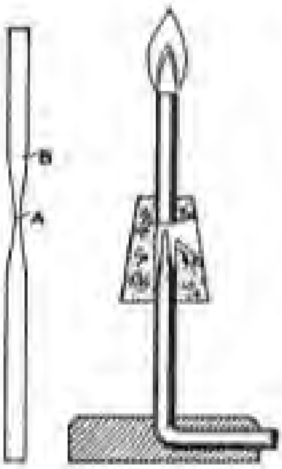
A Small Bunsen Burner

From Popular Mechanix 1915

An excellent bunsen burner for small work can be made as follows: Draw a glass tube to the shape shown, to produce a fine hollow point. Mark carefully with a file and break at A and then at B. Bore or burn a hole in a cork to fit the tube. Cut a V-shaped notch in the side of the cork extending to the hole. Bend the lower tube at right angles and insert it in a wood block, previously slotted with a saw to make a snug fit. A little glue will hold the glass tubes, cork and base together. The air mixture can be adjusted by sliding the upper tube before the glue sets.



Making Bubbles Carry Paper Figures

Popular Mechanics 1925

To make soap bubbles that will carry small paper figures is an interesting pastime. A solution made of soap shavings and water, with glycerin in the proportion of one-third, is used. The solution is placed in a bottle and shaken up until the soap has dissolved, and is allowed to stand until it settles, the clear liquid at the top being used for blowing the bubbles.

The figures are cut from tissue paper and a short piece of thread is attached through the top. The other end of the thread is knotted through a disk of very thin paper. It is best to blow the bubble through a glass tube, and when a bubble of the desired size has been formed, place the paper disk on one side; this will at once slip to the bottom. Shake the bubble off and it starts on its aerial journey carrying the paper figure.—S. Leonard Bastin, Bournemouth, Eng.

THE MEANING OF ATLAN

By KURT SAXON

Legend has it that there was once a great civilization called Atlantis. It is said that Atlantis had a highly developed technology with everything we have and more. Aside from airships, some even have said that they had links with civilizations in outer space.

The story goes on that some great cataclysm destroyed Atlantis. Some say it was from great upheavals in the earth's surface. Others say it was wiped out by atomic war. The great majority of the people died of starvation, riots and wars fought over what was left of civilization.

The survivors, most of whom were highly trained technologists, lost their great cities, industries and technology. This left them helpless and most of them reverted to savagery. From greatness they were reduced to small bands of hunters and gatherers of roots and berries.

Although Atlantis may have been a myth, the further back archaeologists go, the higher the skills acquired by the ancients have been discovered. The cave men, chipping crude flint axes and arrowheads may have been the degenerate descendants of men with knowledge and powers we can only dream of. A good example of this is the degenerate descendants of the Mayas, living like jungle animals in parts of South America today, their ancestors a once proud race, higher in science and mathematics than that of Europe of the same period.

One might wonder how such giants of science and technology as the Atlans could degenerate into the savages archeologists call the "first men".

Ur of the Chaldees, Sumer, Babylon, Egypt, Rome, etc., also rose and then fell with a crash that left their survivors in various states of savagery. They were not as primitive as the cave men since their technologies were more simple and easier understood by the survivors. Even so, the fall of Rome produced a thousand years of what we know as the Dark Ages. Tenth century farmers plowed and planted in the great Roman Coliseum, wondering at the lush harvests. They didn't even remember that that plot of land had been fertilized by the blood of thousands of gladiators and animals slain in the great arena.

Years ago, I was fascinated by how civilizations rose, provided comforts for the populace, erected great monuments to skill and industry and then fell. If they had a system which worked for them, why didn't they go on to ever higher levels of refinement? Why did such powerful nation states as Babylon, Greece and Rome fall to such illiterate savages as the Scythians, early Romans and Huns? Imagine New York City of 1880 being taken over by the Sioux. (I think they could do it today).

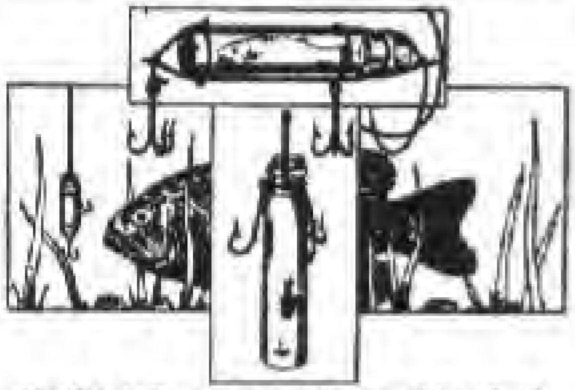
That these once great civilizations did degenerate to the point where they could be overrun by primitive barbarians is a fact. Then, after each fall, the survivors reverted to the most basic of the remaining wisdom, requiring the minimum of knowledge and skill.

The survivors were usually of the peasant class who held on to their poor plots of ground and scratched out a bare living from the soil. Warlike barbarians would descend on such peasant groups and enslave them. Requiring more food for their soldiers, for further conquests, they actually contributed to the growth of agriculture.

Live Bait Used in Fishing

From Popular Mechanics 1915

With the simple device illustrated, no fisherman need worry over running short of bait or even regarding the usual repeated baiting of the hook. A small clear-glass bottle should be procured, and several hooks wired to it about the neck, or at each end, as desired or found best after several trials. After filling the bottle with water a live minnow is placed in it, and the bottle is sealed with a cork, which is notched around the edge to permit water to enter or leave the bottle without losing the bait. If live grasshoppers,



The Bait Is Kept Alive and Unharmed in a Bottle Surrounded with Hooks

or similar bait, is desired the cork can be used unnotched to form a watertight stopper. As illuminated bait for night fishing, several fireflies can be put in the bottle.

Shield for Heater in Chick Brooding House

From Popular Mechanix 1919

A shield of sheet metal, having a small heater in the center of it, provides a good means of warming a brooding house for small chicks. The heat is radiated from the shield and the chicks remain at a distance, seeking a comfortable temperature. The device may be made easily by cutting a sheet of metal to form a cone-shaped hood and fitting it with a vent passing out through the roof of the house.

Gradually, warrior dominated peasants rebuilt civilizations, often far inferior to the previous civilization. Of course, in the beginning of such civilizations, only the strongest and hardiest survived.

But as agricultural methods improved, more people were fed who would have otherwise starved and taken their weaker characteristics out of the gene pool. So unfortunately, this surplus was also the means of preserving weaklings and defectives who should not have survived. Further, such weaklings were enslaved by the ruling classes, and when not being needed for agriculture, drifted to the cities and worked at unskilled jobs or lived on the dole or by begging.

Of course, there were intelligent and skilled artisans and tradesmen in the cities. But the bulk of the population gradually was made up of rejects from agriculture.

The average Roman was jobless, a Proletarian, living on government handouts supplied largely by the Legionaires bringing back grain and other booty from foreign colonies and conquests.

Today, the Proletariat are known as unskilled workers or welfare recipients.

Every culture, as it developed and assumed greatness, nurtured a breed of politicians catering to the useless. Roman politicians financed, through exhorbitant taxes, and even their own wealth, the building of great coliseums, where were held chariot races, gladiatorial combats and various forms of entertainments such as feeding social dissidents, such as Christians to lions. They also had millions of animals collected from all over the then known world. These animals were slaughtered for the enjoyment of the simple-minded Proletarians in the stands. The Romans made extinct literally dozens of animal species.

The greater the show and the more degenerate the acts, the more votes went to the sponsoring Roman politician. Thus, the most degenerate and wasteful politicians gained the most power over the state and its people. "Bread and Circuses" was the method of not only placating an idle and riotous population, but in perpetuating a Senate nearly as corrupt as our own.

The lack of useful work, coupled with the low standards of social acceptability turned a once great nation into a herd of irresponsible, weak-willed, feeble-minded degenerates which were the greatest contributors to the nation's births. In fact, the term "Proletariat" also meant "child bearers".

When the Roman legions reached the furthest areas from which they could loot food from their subject colonies, starvation and social collapse set in.

Thus, Rome fell. Its artisans and intellectuals died out along with its degenerate Proletariat. Then came the Dark Ages ruled by illiterate princes and a corrupt priesthood, both groups of which destroyed as many of the men of reason as they could find, mainly though Inquisitions.

The illiterate princes raped the people through ruinous taxation to fight useless wars with each other and in their stupid Crusades. The Church not only sanctioned these practices, but kept hidden all the knowledge they had collected in the monasteries, which, had they released it, would have done immeasurable good. But their aim was religious domination, not social advancement. Further, the Church chose for its celibate priesthood, the most intelligent youth, whose genes might otherwise have gone to improve the race.

Today, the Church has lost most of its power, although it does its best to encourage the breeding of the poorest and most useless and degenerate of its followers. Happily, though, its loss of influence spares more intelligent men who would otherwise rob our gene pool by celibacy.

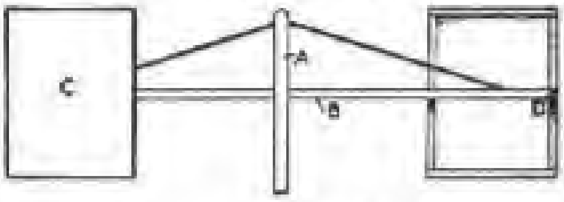
In its place, homosexuality is taking over in the free world, initiating into a life of virtual celibacy many of the best specimens of our youth. Its spread insures the robbing of our national gene pool by limiting future generations to those less attractive, intelligent, and consequently less able to contribute to society.

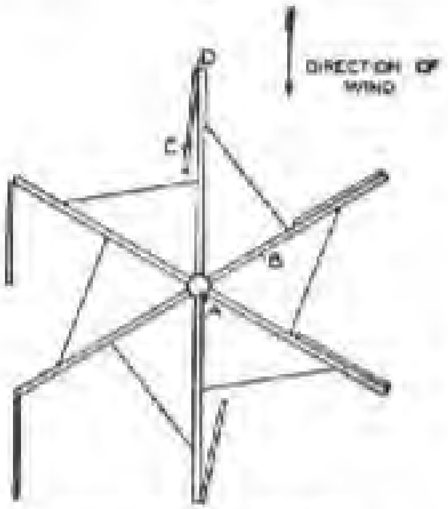
In its turn, our civilization rose from virtual barbarism and has achieved the highest technology in known history. Our previously vast surpluses of food and fuel have led to a surplus population made up largely of the useless and degenerate.

Windmill for Light Power

From Popular Mechanics 1915

The windmill shown in the sketch is one that will always face the wind, and it never requires adjustment. It





Frames Hinged to the Arms

consists of a vertical shaft, A, provided with a number of arms, B, on which are hinged square sails, C. These sails are preferably made of wood frames covered with canvas. They are provided with hinges, D, attached to the ends of the arms in such a way that they offer resistance to the wind on one side of the wheel, while they move edgewise against the wind on the other side, as shown. The shaft of the mill can either be run in bearings set on an upright post, the lower end of the shaft turning on a conical bearing, or collars may be used on the bearings to keep it in position. The power can be transmitted with gears or by a flat belt over a pulley.

A wheel of this kind is not adapted for high speed, but direct-connected to a pump or other slow-working machinery will prove very efficient

SCIENTIFIC AMERICAN CYCLOPEDIA 1891

Candles.—*Adamantine Candles.*—100 lb. of mutton tallow; 2½ lb. of camphor; beeswax, 4 lb.; alum, 3 lb.

Aromatic Candles.—For perfuming apartments.—Melt balsam of Peru and camphor with the material of which the candles are to be made; or the wicks may be steeped in some aromatic tincture and dried.

Cable, Twisted or Spiral Candles.—These are moulded in the ordinary way, and then turned by means of a special lathe; or they may be cast in rifled moulds, from which, on cooling,

Instead of the paradise a controlled population could enjoy indefinitely, our technology is only contributing to the breeding of half-wits, murderous psychotics, Liberals and other perverts who are bringing down our civilization by the year. Adding to this are the changing weather patterns, which will only worsen in our time, plus a growing lack of resources, causing the mass starvation of literally billions of people.

Worldwide collapse of civilization is imminent. It won't happen overnight, but in country by country and area by area, industry by industry, and so on. It could hit you tomorrow. So whether you are an auto mechanic, steelworker or nuclear physicist, you have only a relatively short time in your present occupation. Your survival is up to you.

Years ago I saw the same factors appearing in our society which had led to the collapse of past civilizations. I particularly noted the specialization of the educated, on the one hand, and the frivolous interests and idleness of the less able on the other hand.

I recalled the tales of the fall of Atlantis and its resultant barbarism. Knowing that the ignorant masses were doomed and the more able were locked into an interdependent technology, I searched for answers, as did many of my generation. I became a joiner of cults and causes, giving them all my all. But almost without exception, every faction proved to be a dead end and led by self-serving phonies or psychotic fanatics.

Again recalling the fall of Atlantis, I began preparing a method by which I could provide knowledge to intelligent survivors of the future collapse. My main idea was that the biggest problem facing the survivors would be the lack of knowledge which they could apply to their own circumstances.

As it was, the intelligent survivor could only hope to scrounge sustenance from the ruins. Such scrounging would prove futile in only a short time after the fall.

I hit on the idea of collecting all the practical knowledge of the 19th Century, as it was relatively simple and easy to apply. Also, it would insure a standard of living far from primitive and a springboard to the technology we have today. Further, it is far easier for the layman to understand than modern texts on science and crafts.

Back then, creative and knowledgeable people wrote their instructions for use by anyone interested, whether he had any background in the field or not. Today, books on science and technology are written mainly to those who are expected to be already pretty well grounded on a particular subject.

Also, they wrote in plain language, not showing off their expertise in terms only their fellow experts could understand, as is often done today. Nineteenth Century terms unfamiliar to us were not used to show off, or to conceal knowledge from the uninitiated. They were just the terms people used in those days. Most such old-fashioned terms have been updated in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY.

For years I've been collecting such knowledge and am now, and in the near future, hoping to assemble all the practical knowledge applicable to the needs of future Survivalists.

So Atlan Formularies is simply a figurative reference to the real or mythological Atlantis and a remedy for people in their comparative situation.

After the crash of world civilization there will be chaos and universal suffering and death. Yet, unlike the original Atlans we can revert to a level of technology the intelligent layman can implement.

The only savages will be those who ought not to have been born in the first place. THE POOR MAN'S JAMES BOND will help Survivalists deal with such doomed predators.

GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY will enable you to make the chemical compounds you will need in your daily struggles.

MEDICINES LIKE GRANDDAD USED TO MAKE will help keep you well when your modern doctor loses his contact with the pharmaceutical companies, which will soon be out of existance. (Now part of Chemistry)

SURVIVAL FOODS, PLUS will help you to prepare and preserve the food you will need. (Now part of Survivor Vol. 1) they are wound out.

Cerophane Candles.—Melt over a water bath 50 parts of stearic acid and 5 to 5½ parts of bleached beeswax. Let it remain over the water bath for one-half hour, but do not stir or agitate. Then allow the fluid to cool, until there is a slight film on the surface. Pour the mass into moulds, which have been heated to the same temperature, but avoid stirring.

To Coat Tallow Candles with a Hard Substance which will not Crack.—Dip the candles successively into the following three mixtures: 1. 4 parts white resin; 64 parts good tallow; 6 parts camphor; 20 parts stearic acid; 2 parts dammar resin. Melt.

2. 48 parts tallow; 6 parts camphor; 30 parts stearic acid; 4 parts white pitch; 10 parts dammar resin. Melt together.

3. 20 parts stearic acid; 4 parts white wax; 10 parts tallow; 6 parts camphor. Melt.

Colored Candles.—Among the coloring matters used for candles are the following:

Blue: Prussian blue, indigo, ultramarine, copper sulphate, aniline blue. Red: Carmine, Brazil wood, alkanet root, minium, vermilion aniline reds. Yellow: Gamboge, chrome yellow, naphthaline yellow. Green: Mixture of blue and yellow colors. Purple or violet: Mixture of blue and red colors. Neutral Tints: Oxides of iron, yellow ocher, Frankfort black. Black: Fruit of *Anacardium occidentale*, aniline blacks. In order to dye paraffin candles with an aniline base, such as magenta, the dye is first dissolved in stearin, and a little of the resulting stearate is added to the paraffin.

There are two ways in which candles may be colored black: 1. Anacardium Method.—Paraffin, or whatever material is desired for the candles, is heated from 200° to 210° C. with 1/5 of its weight of the chopped fruit of *Anacardium occidentale*. Candles prepared in this way are equally black throughout, and yield no irritating vapors when burnt.

2. Aniline Method.—The material to be dyed is heated a few degrees above its melting point with 1 to 2% of nigrosine fat color (prepared by Destree, Wiescher & Co., of Brussels). Paraffin and spermaceti require 1%; stearin and wax require from 1½ to 2%. The candles thus prepared are said to be of a somber hue throughout, and of a jet black appearance.

Diaphane Candles.—Melt together in a steam jacket 4 lb. vegetable wax, 8 lb. pressed mutton tallow and 11 lb. stearic acid. The stearic acid and the vegetable wax are the hardening ingredients.

Home Made Candles.—Many of our readers in the rural districts will find that candles can be made economically by mixing a little melted beeswax with the tallow to give durability to the candle, and to prevent its running. The light from a tallow candle can be improved in clearness and brilliancy by using small wicks which have been dipped in spirit of turpentine and thoroughly dried.

Hygienic Candles.—Watson and Fulton prepare them by incorporating iodine and a small quantity of sulphur with the candle material, and they consider that during the combustion the iodine and sulphur are both eliminated in the free state, according to the equation:

$$4\,HI \times SO_2 = I_2 + S + 2H_2O$$

Lard Candles.—1. Dissolve 1 lb. alum and 1 lb. saltpeter in 2 qt. water over a slow fire; 12 lb. lard are added. The stirring must be kept up continually until all the lard is dissolved. Do not leave on the fire too long, as the lard is liable to be discolored. It is said that these candles are superior to tallow.

2. Solid Candles from Lard.—Cut 16 lb. lard in small pieces, put in a pot with ½ lb. alum and ½ lb. saltpeter (previously dissolved in 1 pt. water, over a slow fire). Stir constantly over a slow fire until all the lard is dissolved. Allow to simmer until the steam ceases to rise, then remove from the fire. These candles are harder than those made from tallow.

Mutton Suet Candles in Imitation of Wax.—Throw quicklime in melted mutton suet; the lime will fall to the bottom, and carry along with it all the dirt of the suet, so as to leave it as pure and as fine as the wax itself. Now, if to 1 part of the suet you mix 3 parts of real wax, you will have a very fine, and, to appearance, a real wax candle; at least the mixture could never be discovered, nor even in the moulding of wax ornaments.

Mercurial Candles.—Red sulphide or gray oxide of mercury mixed with wax, and a wick of cotton inserted therein. Recommended by Mr. Colls for partial mercurial fumigation. They are burnt under a glass funnel with a curved neck, the upper orifice of which is directed to the diseased part.

THE SURVIVOR volumes will take care of the daily problems 19th Century people handled with such ingenuity.

In short, my books will give you a level of technology both interesting and practical, useful even today. You need not fear death from want, ignorance or from human predators.

I have been told, and agree, that had I omitted the grimmer aspects of the coming chaos I could reach more people. Selling only nostalgia and 19th Century handicrafts I could appeal to far more buyers and make more money.

But that approach would have had me catering to hobbiests or nostalgia buffs. I'm telling it like it is. I'm not interested in hobbiests or nostalgia buffs. I'm aiming my material at the strong-minded individualist, the only type who can, and should, survive.

I have no political solutions or aspirations. My only admonition to my readers insofar as a future system is to not let another Atlantis happen again. My paramount advice to future generations would be to limit their offspring to only that amount they can provide for and manage with the love and individual care which develops strong citizens.

No social dependent should be allowed to enlarge his dependency. That is, the individual who cannot provide for himself should not be allowed to reproduce.

If this simple rule had been followed there would never have been a surplus population. Hoards of fertile idiots and genetic defectives procreating like unmanaged livestock would not have toppled nearly every civilization I've mentioned.

It is too late for today's majority to escape the fate of Atlantis. But with individual effort and stern measures of population control, Paradise on Earth could be a reality. The next generation, descended from the surviving remnants of this one, could inaugurate the next step in the evolution of human civilization. Then our surpluses could go, not to the upkeep of human vermin, but to the provision of land and well-equipped homes for all, and then even Starships.

Good Sport with a Throwing Stick

By

CHARLES and BERTRAM BROWNOLD

AMONG the weapons of primitive man, the throwing stick is one of the simplest to make and use, and it therefore has all the elements of an entertaining outdoor target game, provided space is available and sufficient precautions can be taken against accidental injury to onlookers.

Prehistoric man is believed to have used the throwing stick, and it has been found among the natives of the upper Amazon regions of South America, in Australia, in Mexico, and among our own Southwestern Indians. The model illustrated here, however, is based upon an Eskimo design, still popular in the Arctic. The throwing stick has remained in use among the Eskimos for centuries because much of their hunting is done in frail kayaks. Aided by the stick, an Eskimo can hurl a spear with great force from a sitting position without endangering his equilibrium even when handicapped by rough water, floating ice, high winds, and extreme cold. A float, usually an inflated bladder, is attached to the spear by a light line. The float guides the hunter to the impaled game and also hinders its escape.

As modified for use in a target game, the throwing stick is simply a ¾" thick piece of wood about 19" long and 2" in width at

Stearine Candles.—These are made of the stearine of stearic acid obtained from tallow, in the same way as other mould candles. They furnish a superior light and burn a long time; three or four years ago it was a general practice for the manufacturer, to add a little arsenious acid (white arsenic) to the stearine, to prevent it crystallizing, and thus spoiling the appearance of the candle; but owing to the spirited way in which this rascality was exposed by the press, it has been discontinued by all the respectable houses.

Tallow Candles.—To make hard tallow candles, use a mixture of mutton tallow, 10 oz.; camphor, ½ oz.; beeswax, 4 oz.; and alum, 2 oz.

Tallow Candles, to Harden.—Dip first in the following: Stearic acid, 50 parts; tallow, 44 parts; camphor, 3 parts; white resin, 2 parts; gum dammar, 1 part. When hard dip in other solution, which consists of 70 parts stearic acid; tallow, 24 parts; camphor, 3 parts; white wax, 2 parts; gum dammar, 1 part. For a final coating dip in 90 parts stearic acid; 5 parts of tallow; camphor, 3 parts; white wax, 2 parts.

Tallow Candles, to Make.—The ingredients are about ½ beef and ½ mutton suet. The use of 1 lb. of alum with each 3 lb. of tallow is recommended. Dissolve the alum in water, then put in the tallow, and stir until both are melted together, then run in moulds. This part of the operation is conducted as follows: The wicks are secured in the center of each mould by passing over two sticks, one of which is laid over the top of the mould (corresponding to the bottom of the candle) and the other against the bottom points of the moulds. The end of the twisted wick is fastened to the stick on the top of the mould, and is drawn by a piece of hooked wire through each mould in succession, leaving a loop outside the bottom points of the mould. The loops are secured there by the bottom stick passing through them; the wicks are to be drawn tight, and the last end tied to the upper stick. The melted tallow is then poured into the moulds and allowed to stand about six hours in a cool place, after which the bottom stick must be taken out of the loops and the candles withdrawn from the moulds. The tallow should not be heated much more than is necessary to melt it.

Wax Candles.—These are made either by pouring melted wax over the wick or by applying the wax in a soft state with the hands, and afterward rolling it smooth with a roller of polished boxwood, upon a table formed of polished walnut wood. They are then cut and trimmed. The first part of the process is usually conducted over cisterns of melted wax, and the wicks are strung upon an iron hoop suspended from the ceiling.

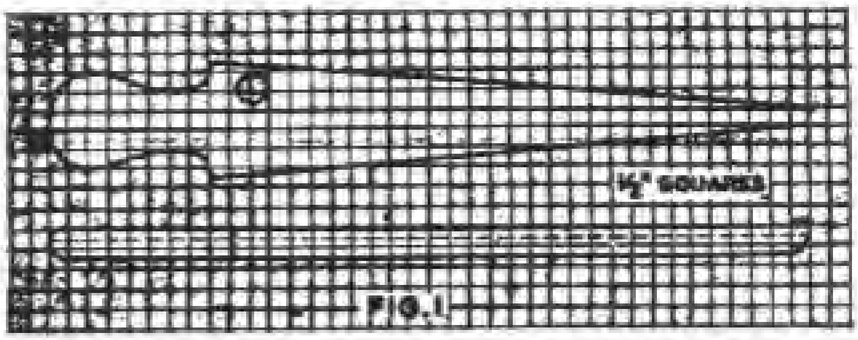
Imitation Wax Candles.—To tallow, purified by throwing powdered quicklime in it when melted, add 1 part of wax to ½ part tallow. This makes a beautiful candle resembling wax. Put 1 oz. saltpeter and ½ lb. of lime in 2 qt. of water. Dip the wicks in this. This prevents the tallow from running, and also improves the light.

Candle Wicks, Preparing.—To improve the light, and prevent the tallow from running, use the following preparation: 1. Steep the wicks in a solution of lime water to which saltpeter has been added in the proportion of 1½ gal. water, 3 oz. saltpeter, ¼ lb. lime. Dry the wicks before using.

2. Borax 3 oz., calcium chloride, saltpeter and chloride ammonium, each 1½ oz.; dissolve in 4½ qt. water, and filter. Soak the wicks in this solution, then dry.

Candles, Scented or Aromatic.—These are prepared by introducing a very small quantity of any appropriate aromatic into the material (fat, wax or wick) of which they are made, while it is in the liquid state. Camphor, gum benzoin, balsam of Peru, cascarilla, essential oils, etc., are generally the substances selected. Care must be taken not to overdo it, as then the candles will burn smoky and give little light.

Candles with Snuffless Wicks.—The great objection to tallow candles is the frequent necessity for removing the snuff, or charred wick, which rises into the body of the flame and obscures the light. If the wick can be exposed to the air, it will be entirely consumed. 1. This is done in composite candles by plaiting the cotton into a flat wick, which as it burns curves over. Sometimes a very fine wire is included in the wick, which is usually dipped in a solution of borax. 2. Twist the wick with one strand shorter than the others, which will bend



Cut the groove first, either half-round or square, to hold the light spear. Shape the handle and bore the finger hole next, as in the pattern; then glue in the block. Taper after the glue has set

Several spears are needed for a competitive game. They are ½" dowel rods 36" long, each fitted with a piece of metal tubing to hold a small sponge, inked for marking the target

its widest point, just beyond the handle. Down its center is a groove for a light spear. The throw, starting with the stick in a horizontal position, is overhand and with a wrist snap. Force is applied to the butt end of the spear, which rests against a stop at the end of the groove—enough force to carry the spear smartly to a target 30 yards away. The stick acts as an extension, or third section, of the arm, making it in a sense half again as long as the natural arm. This permits exertion of a forward thrust on the spear for a longer period, and at the same time the tip of the stick moves through its arc more rapidly than does the hand.

To make a stick, cut a half-round or square groove ⅜" wide and ¼" deep down the center of the wood stock, using a bench saw if one is available. Then shape the handle, bore a hole for the forefinger as shown in the drawing, and glue a small hardwood block tightly into the far end of the groove. After the glue has set, taper the stick to shape.

Spears are ½" dowel rods 36" long. On one end of each is fitted a piece of metal tubing into which is thrust a small inked sponge for marking the target. These targets can be made 24" in diameter from any cheap paper, or else can be purchased.

A few simple rules will help make competition exciting. Draw lines or peg down tape at 20 and 30 yards from the target, and have each player throw three spears from each of these lines for a single round. Stepping over the line is a foul or foot fault, no score being allowed for a foul throw. Score the better mark for a spear that strikes the dividing line between two rings on the target. After six rounds, total the scores to determine the winner. A different colored ink for each player will help in this by automatically identifying all hits.

Be sure that all players and spectators stand behind the throwing line and that no throws are made while spears are being retrieved. The spears are thrown with considerable force, and the metal tips could cause severe injury.

THE BICYCLE: Viable Survival Alternative

by Dr. Spoke

Ever since the "Energy Crisis" began bicycles have gained in popularity, but few people have yet looked into two-wheeled motorless transport as a viable survival alternative for the bigger crisis to come.

Even after the Fall there are likely to be stretches of unbroken pavement, sidewalks, hardpacked woods trails, abandoned railroad rights of way, bridges, tunnels, and whatnot open to bicycle travel. With an easily portable lightweight or folding bike that can be "broken down", the hardy traveler can even pack one on horseback, muleback, ox- or peopleback, on a wagon or in a boat, over wilderness trails to rideable territory beyond, along with necessary weapons and household goods. And any bicycle—even a heavy balloon-tire job—can serve as a welcome adjunct to available motor transport by lessening use of scarce parts and fuel reserves on short and long trips alike.

Lest anybody think bicycles are just glorified kiddie toys, be aware that the Viet Minh and Viet Cong won their wars by manhandling their Peugeots over the Ho Chi Minh trail with up to 500 pounds of freight apiece. The U.S. Army once supported a bicycle battalion. British paratroop commandos executed a successful raid on a Nazi heavy-water installation in Norway using foldup bikes, many big-city police departments sponsor special bicycle patrols in parks and other areas where prowl cars are ineffective, and the "humble" bicycle still outnumbers the automobile in most of the world's countries for transportation, freight hauling and other uses. Bicycles are even used on the largest supertankers for quick hassle-free trips down those huge the wick slightly when the fat melts.

Spermaceti Candles.—Spermaceti, either alone or combined with hard white tallow, forms very good candles, but they will not bear carrying about in the hand without spilling the melted portion.

ACTION OF KREOSOTE ON WOOD

It is well known that kreosote has been applied to great advantage in the preservation of wood for engineering purposes; and a recent writer attempts to show that this is due, first, to its coagulating albuminous substances and fixing the constituents of the cambium and cellulose of young wood; second, to its abstracting and appropriating the oxygen in the pores of the wood, and preventing its action upon the woody tissue; third, to its resinifying within the pores of the wood, and thus excluding both air and moisture; fourth, to its acting as a positive poison to the lower forms of animal and vegetable life, and protecting the wood against the attacks of all parasitic objects. It is stated that the formidable ravages of the white ant are prevented by the use of this substance, and that it may be considered as solving all the problems presented in regard to the preservation of wood, under all circumstances.

INFLUENCE OF TREES ON RAIN-FALL.

The marked influence of forests upon the amount of rain-fall of a country has recently received a striking illustration in the experience of the Australians. The result of destroying the timber in the Ballarat district has been to cause a reduction of the rain-fall from thirty-seven and a half inches, in 1855, to fourteen and one-quarter inches in 1868. To remedy the difficulty, and to take proper action for restoring the forests, an inspector of state forests has been appointed by the government, for the purpose of preventing any further waste of timber, and of replanting forest trees in different parts of the country.

ABSTINENCE.—Disease may oft be cured by abstinence from all food, especially if the disorders have been procured by luxurious living and repletion. The latter overtaxes nature, and it rebels against such treatment. Indigestion, giddiness, headache, mental depression, &c., are often the effects of greediness in meat and drink. Omitting one, two, or three meals, allows the system to rest, to regain strength, and allows the clogged organs to dispose of their burdens. The practice of drug taking *to cleanse the stomach*, though it may give the needed relief, always weakens the system, while *abstinence* secures the good result, and yet does no injury.

Said a young gentleman to a distinguished physician of Philadelphia,—'Doctor, what do you do for yourself when you have headache, or other slight attack?' 'Go without my dinner,' was the reply. 'Well, if that will not do, how do you proceed then?' 'Go without my supper,' was the answer. 'But if that does not cure you, what then?' 'Go without my breakfast. We physicians seldom take medicines ourselves, or use them in our families, for *we know* that *starving* is better, but we cannot

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quarter-mile decks!

But even the least migratory survivalist will find a bicycle indispensable in his homestead or business. Knife sharpeners in England utilize a small grindstone attached to a chaingear run off the rear wheel of their machine to ply their trade, and an enterprising survivalist could do this with very little effort. He could take additional advantage of fuelless pollution-free "pedal power" by using a stationary bike to turn a generator for electricity, or even gearing one to a circular saw for woodcutting. With the appropriate gears on a multi-speed bike, the operator of such equipment needn't even raise a heavy sweat! But if it's exercise you want, a bicycle on a stand is an ideal way to pass long winter months or states of siege without the inconvenience of going outdoors; you can pedal hundreds of miles right in your own living room.

Parts for bicycles are very likely to be available from junkyards, old or abandoned machines, and other sources, even when car and motorcycle parts are not, but it's still a good idea to prepare in advance by gathering up frames, wheels, tires, cables, etc. NOW. After the Fall they will be invaluable for barter and a good bicycle mechanic will be as necessary to his home and community as the farmer, blacksmith, and weapons expert. But even the rankest novice will find bicycle maintenance and repair are a snap compared to looking after any motorcycle or car. For starters I'd recommend the simple little paperback "How to Fix Your Bicycle" by Helen Garvey and Ted White, available for only $1.00 at most bike shops. This little gem gives easy-to-follow pictures and text to help the beginner solve almost any common bike repair problem—even to spoking your own wheels.

For do-it-yourself repair and maintenance of a two-wheeler only a few special tools are needed. Some old English and American (Schwinn) bikes use standard-measure tools, but most all of the newer and imported machines are metric. If you already have a car then you hopefully have a tool kit for it and most of these (sockets and wrenches) are perfectly adaptable for bicycle work. Get a metric set if your car is American. The only really special bike tools you need buy, unless you intend to set up a shop, are a chain remover tool, a freewheel extractor and a "cotterless crank tool" (all of these are specifically for 5 and 10 speeds), and a tire repair kit, cone wrenches, spoke wrench and punch for most all bikes. A more complete description of these and other tools can be found in the Garvey and White book I mentioned above.

With just a little work and ingenuity, every member of a household old enough to ride can have his or her own bike or share the use of one or more "common" bikes. I would even recommend that various types of bikes be used for different tasks depending on availability and rider preference: adult three-wheelers with carrying baskets for transporting farm products, tools, weapons, and other bulky stuff; 5 and 10 speeds for faster travel and longer trips, especially in hilly country; one or three speeds for flatter terrain and shorter trips; tandems for groups; and even Motocross bikes and mopeds. "Motocrosses" are bicycles with reinforced, heavy frames built like dirt motorcycles but without the motor, and while heavy and cumbersome will last practically forever; "mopeds" are powered by tiny engines of one hp or so and are just the ticket for frail riders who find regular bicycles too slow or tiring. They get over 160 mpg when motoring or can be propelled by auxiliary pedals with the engine off. There are several types (European and Japanese) available in the U.S. and all are fairly expensive ($400+) compared to most regular bikes, but their potential usefulness and simple upkeep (compared to cars and motorcycles) might justify the initial cost, especially when gas is scarce.

Even a lightweight 10-speed can carry a lot of stuff in frame-mounted baskets or attached bicycle trailers (manufactured or improvised). Light-weight front and back carriers are also available, the Jim Blackburn tubular aluminum model being the best, lightest, and costliest. I sincerely recommend puncture-proof tubes with sturdy tires and steel rims to stand up to rough usage and minimize flats on long trips, because a flat tire is no fun even with a patch kit handy. Good lights and reflectors are also essential, even if you don't plan to travel at night. No bicycle light is perfect and most are shabby and not worth a damn, but long years of experimenting have seen me improvise a few good ones using six-volt waterproof hunting lanterns. I recently rigged up a dandy unit able to run on either straight batteries or off a lightweight generator, thus overcoming the drawbacks of either system alone (batteries lose juice when cold and generators conk out when wet). I use a rather expensive sealed-beam diver's lamp, but an inexpensive six-volt flashlight will suffice quite nicely.

Following is a short bibliography for those who want to look further into bicycles and bicycle history. The publications marked * are especially good for beginners and should be available at most bike shops. Prices listed are as of

December, 1976. All other books should be readily available at any good library.

Alderson, Frederick. **Bicycling: A History**; Praeger Publications, NY, 1972 "BMX" Soldado Publications, City of Industry, CA. 1974 Book on Motocross Caidin, Martin and Jay Barbree. **Bicycles in War**; NY Hawthorne Books 1974 Cuthbertson, Tom. **Bicycle Tripping**; Ten Speed Press 1972 $3.95. "Bicycling"* Western Publishing Co. NY 1974 $2.95. "The Bicycle Book"* Price/Stern/Sloane Pub. Los Angeles 1972 $1.50. **Coaster and 3 speed Bicycle Repair**; Xyxyx Pub. Canoga Park CA. 1972 $3.95. "How to Fix Your Bicycle"* (Helen Garvey & T. White) Shire Press (SF) 1971 $1.00. Humphrey, Clifford C. **Back to the Bike**; 101 Publications (SF) 1972. Sloane, Eugene A. **The Complete Book of Bicycling**; Trident Press NY 1970. Smith, Robt. A. **A Social History of the Bicycle**; American Heritage Press. Woodforde, John. **The Story of the Bicycle**; Universe Books, NY 1970.

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make our patients believe it.'

Hippocrates (the father of medicine) said wisely, that if a man eats sparingly and drinks little, he is nearly certain of bringing no disease upon himself, and that a *moderate* supply of food nourishes the body best. The quantity of food which nature really requires for her support is small, and he that eats and drinks moderately at each meal, stands fair to enjoy sprightliness, vivacity, and freedom of spirits. Bodies governed by temperance and regularity are rarely hurt by melancholy, or any other affection of the mind. To have a clear head we must have a clean stomach; for this is the grand reservoir in which the food is first deposited, and thence its nutritive power is distributed throughout all parts of the body.

ACETOUS CATAPLASM, or POULTICE.—This is made with vinegar and bran only, or with the addition of oatmeal, or bread crumbs. It is a simple poultice, but very useful for sprains and bruises. As it becomes dry, it should be moistened with vinegar.

ÆOLIAN HARP, To Manufacture an.—Let a box be made of thin deal, the length to correspond exactly to the breadth of the window in which it is to be placed, five inches in depth, and six in width. Glue on it at the extremities of the top two pieces of oak about half an inch high and a quarter of an inch thick, to serve as bridges for the strings, and within-side of each end glue two pieces of beech, about an inch square, and of length equal to the width of the box, which is to hold the pegs. Into one of these bridges fix as many pegs (like those of a violin) as there are to be strings, and into the other fasten as many small brass pins, to which attach one end of the strings. Then string the instrument with first-fiddle strings, fixing one end of them and twisting the other round the opposite peg. These strings, which should not be drawn tight, must be tuned in unison.

To procure a proper passage for the wind, a thin board, supported by four pegs, is placed over the strings at about three inches distant from the sounding board. Place the instrument in the window partly open; and, to increase the force of the current of air, open the

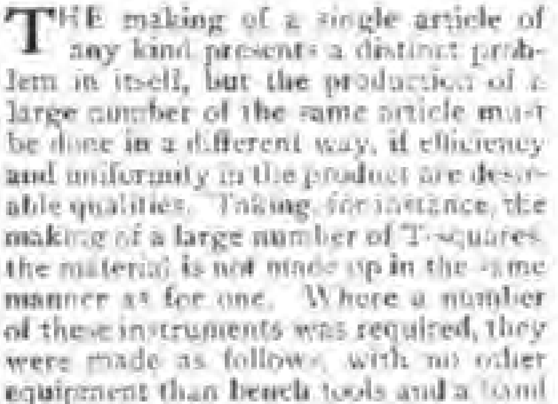
Making T-Squares

From Popular Mechanix 1919

BY J. B. MURPHY

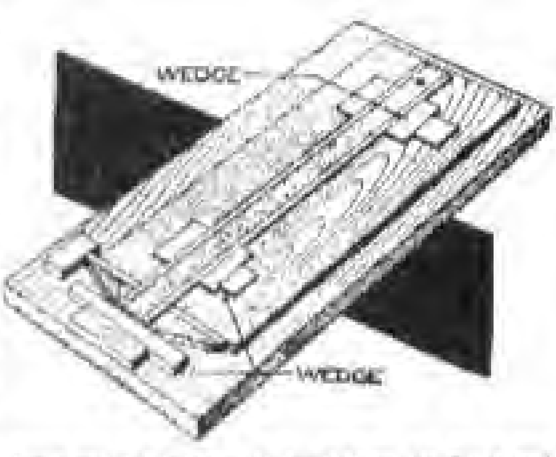
THE making of a single article of any kind presents a distinct problem in itself, but the production of a large number of the same article must be done in a different way, if efficiency and uniformity in the product are desirable qualities. Taking, for instance, the making of a large number of T-squares, the material is not made up in the same manner as for one. Where a number of these instruments was required, they were made as follows, with no other equipment than bench tools and a band saw. The squares were made of mahogany having both stock and blade edged with maple. The blades were fastened to the stock with five ½-in. button-head screws.

The material for the heads and the



Dimensions for a T-Square of Which a Number were to be Made in Duplicate

blades was glued up and finished to the sizes given at A and B. The material was cut to gauge lines on the band saw, the blades being a scant ⅛ in. in thickness, and the stocks, ⅜ in. Two of each were cut from each prepared piece, first from one side and then from



Stock and Blade Material for Making the Parts, and the Jig for Assembling

the other. They were then faced off on both sides, and two more pieces cut. With careful cutting, six blades and six stocks were made from each piece. This left one side of each piece to be planed after sawing. The holes for the screws were drilled with a small hand drill.

For assembling, a jig was made by nailing a piece of stock, ⅜ in. thick, to a straight drawing board. One end of the piece was planed straight and true before it was fastened in place. Stops were provided to locate the stock and hold the blade square with it. Wedges were used to keep both stock and blade against the stops while the screws were inserted. The wedges were not driven with a hammer, but pushed in firmly with the fingers.

door of the room or an opposite window. When the wind blows, the strings produce a pleasing admixture of all the notes of the diatonic scale, in the most delightful harmonic combinations.

ALE, FINE WELSH, to brew. —Pour forty-two gallons of water, hot, but not quite boiling on eight bushels of malt, cover and let it stand three hours. In the mean time infuse four pounds of hops in a little hot water, and put the water and hops into the tub, and run the wort upon them, and boil them together three hours. Strain off the hops, and keep for the small beer. Let the wort stand in a high tub till cool enough to receive the yeast, of which put two quarts of ale, or if you cannot get it, of small-beer yeast. Mix it thoroughly and often. When the wort has done working the second or third day, the yeast will sink rather than rise in the middle, remove it then, and tun the ale as it works out; pour a quart in at a time, and gently to prevent the fermentation from continuing too long, which weakens the liquor. Put a bit of paper over the bung-hole two or three days before stopping up.

Ale, or Strong Beer, to brew.—Twelve bushels of malt to the hogshead for beer, (or fourteen if you want it of a very good body), eight for ale; for either pour the whole quantity of water, hot, but not boiling, on at once, and let it infuse three hours close covered; mash it in the first half-hour, and let it stand the remainder of the time. Run it on the hops previously infused in water, for strong beer three quarters of a pound to a bushel; if for ale, half a pound. Boil it from the wort two hours from the time it begins to boil. Cool a pailful to add three quarts of yeast to, which will prepare it for putting to the rest when ready next day; but if possible put together the same night. Tun as usual. Cover the bung-hole with paper when the beer has done working; and when it is to be stopped, have ready a pound and a half of hops dried before the fire, put them into the bung-hole, and fasten it up. Let it stand twelve months in casks, and twelve months in bottles before it be drank. It will keep fine eight or ten years. It should be brewed the beginning of March.

Great care must be taken that the bottles are perfectly prepared, and that the corks are of the best sort.

The ale will be ready in three or four months; and if the vent-peg never be removed, it will have spirit and strength to the very last. Allow two gallons of water at first for waste.

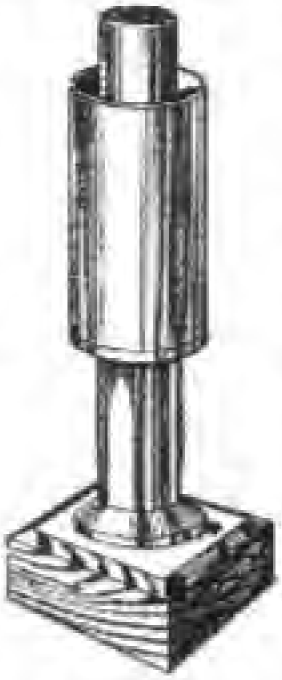
After the beer or ale has run from the grains, pour a hogshead and a half for the twelve bushels, and a hogshead of water if eight were brewed; mash, and

Continued page 488

A Simple Self-Contained Motor

From Popular Mechanix 1919

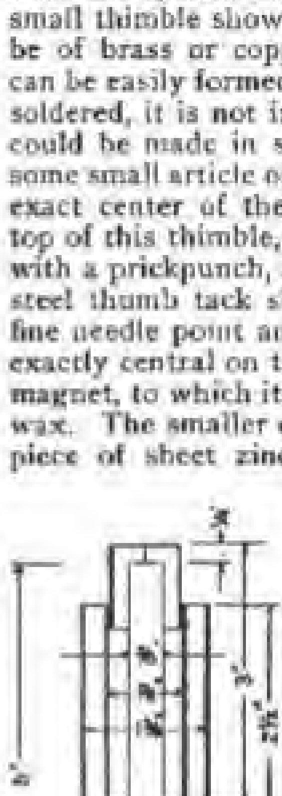
To say that the subject of this article is the simplest motor in the world is not to overestimate it, for the apparatus is not only a motor reduced to its essential elements, but combines within itself its own source of electric power, all without the use of a single piece of wire. The experiment is very interesting and instructive and will well repay a careful construction along the lines indicated, even though not in strict accordance with the dimensions given.



The first step is to procure a permanent magnet, about ⅝ in. in diameter and 6 in. long. If such a magnet cannot be conveniently secured, a piece of tool steel with flat ends should be hardened by heating it to a dull red and plunging it in water, and then strongly magnetized. This may be readily accomplished by slipping a coil of insulated wire over it through which the current from a storage battery or set of primary cells is passed. If these are not at hand, almost any electrical supply store will magnetize the steel.

A square base block with neatly beveled corners is now in order, which is trimmed up squarely and a hole bored centrally through it to receive the lower end of the magnet. Procure a neat spool and make a hole in it large enough to pass over the magnet. Glue the spool to the base after locating it in the exact center.

The outer and larger cylinder is of copper, or of brass, copperplated on the inside. It is cup-shaped, with a hole in the bottom just large enough to permit the magnet to be pushed through with a close fit, to make a good electrical contact. The magnet may be held in place by having it closely fit the spool and the copper cylinder, and by soldering the heads of a couple of small tacks, or nails, to its under side and driving them into the spool. Coat the magnet with pitch, or paraffin, from the top down, and around its connection with the bottom of the cylinder. The small thimble shown at the top should be of brass or copper, and while one can be easily formed of sheet metal and soldered, it is not improbable that one could be made in seamless form from some small article of commerce. In the exact center of the under side of the top of this thimble, make a good mark with a prickpunch, after which a small steel thumb tack should be filed to a fine needle point and placed, point up, exactly central on the upper end of the magnet, to which it is held with a little wax. The smaller cylinder is simply a piece of sheet zinc bent into a true cylinder of such a size that it may be sprung over the lower end of the thimble. This done, it is only necessary to slip the zinc over the end of the magnet until the thimble rests on the thumb tack, and then pour some dilute muriatic or sulphuric acid into the outer cylinder, after which the thimble and attached zinc will begin to rotate. The required strength of the acid and the resulting speed will depend upon the nicety of suspension and the trueness of the rotating zinc cylinder. The zinc will have to be changed, but the copper undergoes no deterioration.



PRESERVATION OF GRAIN AND SEED IN VACUO.

Some time since Dr. Louvel, of France, proposed the use of vacuum reservoirs for the permanent and definite preservation of seeds and grain of all kinds. Further experiments have been made in this direction, and it seems to be pretty well ascertained that the process has an economical value; and that while the necessary vessels can be made of large size at a moderate cost, the process of exhaustion of the air also costs but little; and once treated in this way the seeds can remain an indefinite number of years without further attention, with a certainty that all the elements, chemical or vital, of the grain will be properly preserved.

APPLYING PAINT TO PLASTER CASTS.

Porous plaster or stone may be rendered compact, and fitted to receive paint by applying a coating of a solution of one part albumen in five of acetic acid. The result is a fine, firm, adherent skin, upon which the paint may then be laid.

Preview of life in coming dark age

Western civilization doesn't have to blow itself up to tear itself down, according to Roberto Vacca. In his book "The Coming Dark Age," the University of Rome electronics and computer expert predicts a massive breakdown of our enormously complex technological systems between 1985 and 1995—a "knockout" resulting in a return to a primitive way of life. The quality that sets Vacca's book apart from many Prophet-of-Doom manifestos is the logic with which he describes not only the coming technological collapse but also its aftermath. In the following excerpt, "Preview of Life in the Coming Dark Age," he speculates on the problems facing the survivors of a catastrophe we may not be able to avoid.

* *

By ROBERTO VACCA

It is not necessary for a few kilomegatons of hydrogen bombs to explode for hundreds of millions of people to be killed.

The same result may occur by less violent and more intricate means: that is, by virtue of the fact that vast concentrations of human beings are involved in systems that are now so complicated that they are becoming uncontrollable. This hypothesis—of an apocalypse that is impersonal, casual, and unpremeditated—is more tragic than the other.

My thesis is that our great technological systems of human organization and association are continuously outgrowing ordered control; they are now reaching critical dimensions of instability. As yet, a crisis in a single system would not be enough to bring a great metropolitan concentration to a halt.

But a chance concomitance of stoppages in the same area could start a catastrophic process that would paralyze the most developed societies and lead to the deaths of millions of people.

One cannot demonstrate a priori, of course, that a chance coincidence of events—decline, congestion, and slowdown—must lead inevitably to disaster: not, at least, in a developing situation such as I describe. It seems very likely, however, that the most developed nations are on the way toward breakdown on a large scale.

Countries that are less advanced than others (either on the way to modernity, or still underdeveloped, or just backward) will only be involved in the crisis to a marginal extent. Seventy per cent of the population of the world will not be much injured by the first wave of destruction.

On the other hand, the more advanced nations will be more vulnerable to the harm that will accompany the breakdown of the great systems: in the dark age that would follow, their total population might be halved.

Since these nations would include Europe and the Soviet Union, North America and Japan, some 900 million people would be involved, or about 30 per cent of the present population of the world.

The death of 450 million people in the world's most developed countries would mean that scientific development, technological research, large undertakings in civil engineering, industrial mass production at low cost, the whole organizing and directive structures that function in modern society, would come to a complete stop.

Along with a certain setback that the countries of the Third World would suffer, there would be grave secondary consequences: manufactured goods, finished and durable products, medicines, production facilities and managerial know-how previously supplied by the more advanced nations—all would be missing.

There is one fact that will bring notable relief to many survivors: the grim problems facing them will at least be completely different from those that have been tormenting them in past years.

The problems of an advanced civilization will be repalced by those proper to a primitive civilization, and it is probable that the majority of survivors may be made up of people particularly adapted to passing quickly from a sophisticated to a primitive type of existence.

The first benefit to be enjoyed by the surivvors will be the end of congestion: there will be too few people left in circulation to cause any congestion at all.

One must point out, however, that many who now deplore the oppression, injustice, and intrinsic ugliness of life in a technically advanced and congested society will decide that things were better when they were worse; and they will discover that to do without the functions proper to the great systems—without telephone, electric light, car, letters, telegrams—is all very well for a week or so, but that it is not amusing as a way of life.

To some of the survivors it will be an obvious advantage that so many durable goods will be available in excess of demand. The death of the greater part of a city's population will make houses and dwellings of all types available far in excess of need.

If, before the knockout (KO), there had been on an average one car to every two inhabitants of a city, after the KO there will be some two or three cars per head, and for a time the survivors will be able to satisfy their transportation needs simply by using one of the many abandoned vehicles. The car industry will disappear.

Later, when old cars have been used up and there are no new ones, abandoned cars will be the obvious source of spare parts, until new needs begin to renew industrial production. Then, production will be on a small artisan scale, fulfilling small commissions or making single parts.

Buildings will show a similar gradual breakdown — an initial superabundance resulting in the disappearance of building as a great industry. A small number of people, forced to rely on themselves, will be unequal to the adequate maintenance of the buildings they are using: and they will give no attention at all to those they are not using.

Empty buildings will be raided for fixtures or odd pieces having some structural value; and this, along with damage due to weather, will cause collapses. These will bring down other, inhabited buildings.

In the long run, therefore, houses will be much scarcer than they were before the KO, and new ruins will become a typical feature of the urban landscape. Ancient and noble ruins will be covered and obliterated by new ones in accordance with a process that was familiar in the former Dark Ages.

Vandalism will add to collapse and destruction in cities; and inasmuch as it will not cause direct harm it will not be punished, but will be one of the few entertainments still available to the young.

After the KO, as during the original Dark Ages, the distinction between new and secondhand objects will lose the great importance that it has at present. The only distinction will be between things that are effectively usable and those that are broken and beyond repair.

Again, this will happen at first because of the availability of many secondhand things in good condition. Then new objects will become extremely rare, so that there will no longer be anything derogatory about the term "used."

Further, new products will often be of much poorer quality than used products made of better material and in accordance with finer methods of production.

Before the KO the standard of living reached by a large number of people in the advanced nations made it respectable for them to buy books and antiques secondhand, but certainly not clothes: to acquire a used garment was almost unthinkable. After the KO used clothes would not only be bought or bartered; they would be heirlooms.

One hopes that at least this new state of things will gratify today's detractors of consumerism and all who are annoyed (perhaps not unreasonably) that fashion should be so powerful in the field of consumer goods.

A very severe restriction of the movement and use of cars will follow from the scarce and irregular availability of oil products and gasoline.

As a consequence, journeys for pleasure will become very rare and will be reserved for the powerful or for tramps who will have to go long distances on foot. There will be a large increase in the percentage of people who have never moved from the place where they were born, neither for work, nor for sightseeing, nor for any other reason.

The scarcity of travelers will provide opportunity for the revival of brigandage. Pilgrimage will be the motive for undertaking fairly long journeys.

Indeed, we may expect that the new dark age will favor the revival of a religiosity as simple as it will be widespread, and expressed in forms that today are unforeseeable.

In the field of economic relationships an important element in the modern consumer structure that will be missing at once is credit. In conditions of extreme instability, no one could possibly give a creditor meaningful guarantees of future payment with interest.

It is very likely that at first all forms of money will lose whatever value they have and that exchanges will be solely by barter. There intrinsic rarity will suffice to keep gold and silver coins in use, and the old convention would be reestablished whereby the weight of coins and ingots would be the sole determinant of their value: every merchant would include in his office equipment a small balance for weighing gold and silver.

Short-term advantages can accrue to the so-called developing countries inasmuch as they are actually subject to, colonized by, or oppressed by more advanced countries on their way to regression. When the regression of the advanced nations becomes effectively obvious, their oppression of others will cease and the less developed nations will experience relief.

But it will probably be brief, because in the long run much graver problems will emerge, not only because finished products from the regressing countries will then be lacking, but also because generalized armed conflict is likely to be the pattern, either between nations in retrogression, or between those that have not yet advanced, or — at a more microscopic level — between cities, villages, or families, and between individuals.

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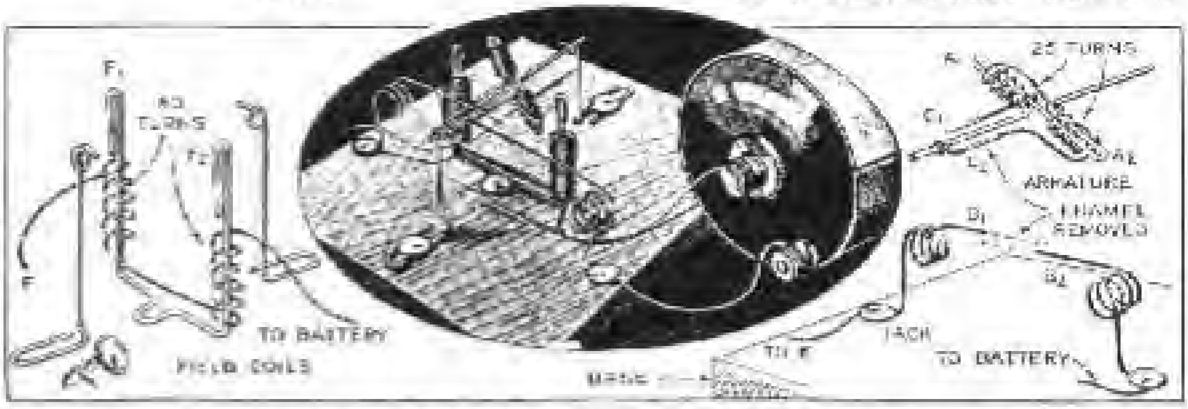
A Real Electric Motor for a Cent

From Popular Mechanics 1937



The Framework of This Small Motor Is Made from Paper Clips, While Enameled Copper Wire, Wound on the Poles of the Field Coils and Armature, Is Also Used for the Brushes and Commutator

Electroplating Non-Metallic Objects

THERE are innumerable non-metallic objects, such as flowers and fruit, wooden novelties, glass and plaster knickknacks, leather articles, etc., that can be given a beautiful and lasting finish by electroplating, if they are properly prepared before suspension in the bath.

The most important part of the process consists in giving the object a coating that will conduct electricity. The coating may be either sprayed on or applied with a camel's-hair brush. To 1 pt. of thin, clear cellulose lacquer add 1 oz. of copper powder. Commercial cellulose lacquer is often too thick and should be diluted by adding lacquer thinner until the right consistency for spraying is obtained. The mixture may be slightly thicker if it is to be applied with a brush. Some bronze powders, sold as copper powder, have an aluminum base and are not satisfactory for this purpose. The pure copper powder can be bought at a chemical house. The mixture should be thoroughly stirred before it is applied so that all the powder is held in suspension. This mixture is a conductor of electricity and does not offer much resistance. When the coating has dried, the object may be plated with a heavy deposit of copper, after which a surface coat of gold or silver can be added, if desired. Before the cellulose-and-copper coating is applied, the object should be thoroughly dried. Wooden objects should be boiled in linseed oil, which prevents the base coat from soaking in and cracking

MADE from ordinary wire paper clips and No. 26 enameled wire, this small electric motor takes only a few minutes to construct. It is a series motor and will run either on a. c. or d. c. at a low potential, such as that provided by a single dry cell.

The framework for the field coils and the armature are first made from paper clips bent to the shape indicated, and the armature supports are then made in a similar way. Wind 50 turns of enameled wire on F_1 and F_2, the direction of winding on these poles being opposite and both coils being connected together. The free end of one coil is connected to the battery while the end of the other coil, marked F, connects to one of the armature brushes B_1, shown in the lower right detail. The armature is wound next, 25 turns of wire being wrapped on poles A_1 and A_2, both coils being wound in the same direction and terminating at C_1 and C_2, where the enamel is removed from the wire, leaving the bright copper surface which forms the commutator. The brushes B_1 and B_2 are simply lengths of enameled wire with the ends brightened to form good electrical contact and wound in a spiral form, as indicated, to produce a spring effect which causes the ends to make good contact with the commutator. The field-coil frame, the armature supports and the brushes are then fastened to a wooden base with thumbtacks, and the armature is slipped in position. Carefully adjust the brushes so that they will touch the commutator lightly, the proper tension at this point being highly important. Now hook up B_2 to the other terminal of the battery and the motor will run if it has been correctly wired and properly adjusted.

The operation of the motor can be greatly improved by having the coils on the armature balanced as closely as possible and spaced exactly the same distance from the center. This point should also be taken into consideration when forming the armature frame. The small eyes at the end of the armature supports, which serve as bearings, should make a loose fit on the armature shaft, and light machine oil may be used here to reduce friction. Drops of solder at the ends prevent the shaft from slipping out.

the wood. Plaster-of-paris objects, which might be affected by the electroplating solution, should be slightly warmed in an oven to remove all moisture and are then dipped in hot wax or paraffin after which the copper lacquer is applied. This waxing treatment should not be given to fruits or flowers, as much of the surface detail would be destroyed.

One electroplater has produced some gleaming chromium drumsticks that are very popular. The sticks are turned out of light basswood, boiled in linseed oil, and painted with the copper-lacquer mixture. They are then given a 1/64-in. layer of copper, a thin coat of nickel, and a final plating of chromium. The sticks are placed slowly to obtain a smooth surface and are buffed between each plating operation. A weight is hung on each stick so that it will sink when placed in the plating bath. When the sticks are finished, they have about the same weight as hickory, and are practically unbreakable.

If the object to be plated has no base to which the electrical connection can be made, the conducting wire should be wrapped around it loosely and the position of the wire should be changed after each plating process, so that any unevenness on the surface, made by contact with the wire, can be buffed off, as in Fig. 4.

If the object has a base, a more satisfactory connection for the first heavy coat can be made by attaching the conducting wire to the base with a small amount of heated dental wax. The wax hardens and holds the wire in place firmly so that it can be suspended in the bath as in Figs. 2 and 3. The copper-lacquer mixture should also be painted over the wax and around the wire. This connection can be broken out after the first plating process and the wire wrapped around the article, as already mentioned, for applying the succeeding coats.

An interesting table ornament is made by gluing a few pebbles in the bottom of a small saucer and inserting a branch among them to represent a tree. Small pieces of rubber sponge glued to the branch make realistic clusters of leaves. By dipping the articles in wax and then painting them with the electrically conducting coat, the piece may be finished by plating it with silver.

MAKE A HANGMAN'S NOOSE AND ROPE HANDCUFFS

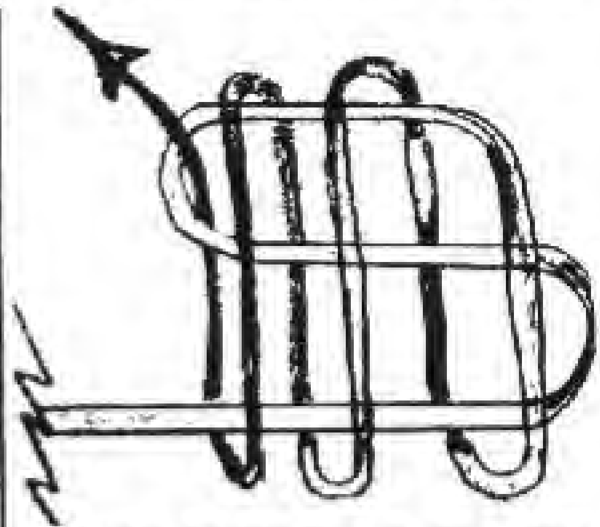
By A.D. Robinson

One knot that seems to hold a perverse fascination to some is the hangman's noose. It works by the slamming action of the coils striking the victim's neck, and in so doing, breaking it. An interesting sidenote is that many states have laws that attempt to regulate the number of coils a hangman's noose may have, the idea being to prevent unauthorized lynchings.

Since I've been going on about the hangman's noose, you are doubtless itching to make one of your own. To start, take some string, rope or what have you and lay it out on a flat surface as shown below:

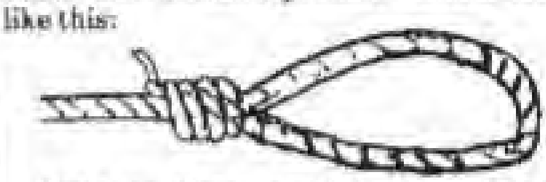
The drawing is sideways in the interest of saving space. During your first few attempts, points A, B, and C should be held stationary to prevent frustration from too many fouled knots. You can tape the points to a table or desk if you are using string, and tent pegs or similar, work well for rope. There should be a goodly amount of slack on the end that is pointed on the drawing; enough to make as many turns as desired. Don't worry about having too much excess; it is easily taken up when the knot is finished.

For your next step, make the following bends:



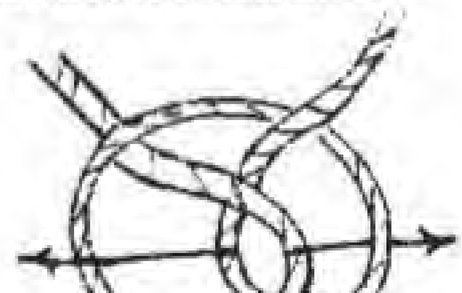
The number of turns are variable, but you get the idea. It seems awkward winding the coils around the thrice bent rope, but this feature is helpful to prevent breakage during use. You can see how embarrassing that would be, can't you?

Once you have completed your rope manipulations, the coils are pulled tight, most of the slack is cut off and the thing is done. The finished product should look like this:

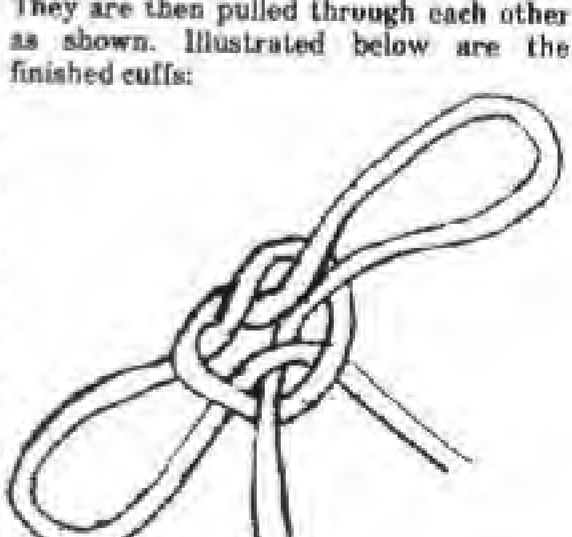


Don't be discouraged if yours doesn't look fit to appear on "Bonanza". As you practice, your skill will improve and you will be making perfect specimens with ease.

Another fun project in knot tying, and equally amusing, are the rope handcuffs. They are amazingly simple and might even come in handy someday. They are made by laying down two loops, the second on top of the first, like so:



They are then pulled through each other as shown. Illustrated below are the finished cuffs:



The victim's wrists are put inside the two nooses. The ends are pulled tight and knotted.

I trust you, the reader, to find many clever uses for both knots.

let it stand, and then boil, &c. Use add one teaspoonful of the powder to every pound of flour, and knead it well. By this powder hot rolls may be had to breakfast every morning, as its action is so rapid. Keep the powder in a well corked-bottle.

BEER, Excellent Table.—On three bushels of malt pour of hot water the third of the quantity you are to use, which is to be thirty-nine gallons. Cover it warm half an hour, then mash, and let it stand two hours and a half more, then set it to drain. When dry add half the remaining water, mash and let it stand half an hour, run that into another tub, and pour the rest of the water on the malt, stir it well, and cover it, letting it infuse a full hour. Run that off, and mix all together. A pound and a half of hops should be infused in water, and be put into the tub for the first running.

Boil the hops with the wort an hour from the time it first boils. Strain off and cool. If the whole be not cool enough that day to add the yeast, a pail or two of wort may be prepared, and a quart of yeast put to it over night. Before tunning, all the wort should be added together, and thoroughly mixed with the lade-pail. When the wort ceases to work, put a bit of paper on the bung-hole for three days, when it may be safely fastened close. In four weeks the beer will be fit for drinking.

Note. Servants should be directed to put a cork into every barrel as soon as the tap is taken out, and to fasten in the vent-peg, the air causing casks to become musty.

BILIOUSNESS. — The first thing is to allay the irritability of stomach; second, to evacuate the bowels of their acrid matter; third, to remove spasms, irritation, or urgent symptoms; fourth, to excite a healthy secretion of the liver. For these the *Neutralising Mixture* (see page 275.) will be found applicable for the purpose; give a small tablespoonful every half hour, or as often as the vomiting occurs, and when allayed take a good purgative; such as 1 oz. of castor oil, or a strong dose of Rhubarb; or a purging mixture: Glaubers salts, ½ oz.; Epsom salts, ½ oz.; spearmint water 5½ ozs.; antimonial wine, 2 drachms; tincture of senna, ½ oz.; mix, and take 2, 3, or 4 tablespoonfuls for a dose, every 3 hours until it operates. If these do not act recourse must be had to injections composed of:—Sweet milk, 1 pint; mucilage of slippery elm, 1 pint; olive oil, 1 gill; molasses, ½ pint; common salt, 1 oz.; mix. Use a large size syringe. Should there be great pain in the lower intestines add a drachm of laudanum to each injection, it will relieve the griping pain. Introduce as much of the injection as the patient can bear, to be repeated every hour or two until the

SURVIVAL ELECTRONICS

The following is presented to the person concerned with defending an area such as his home or farm. It is not aimed at the person who, in a disaster, heads for the hills with a knife in his teeth.

During any period of distress, it is important to know what is happening around you. Since almost all communications today are electronic, I will try to present some ideas about the simpler things that can be done.

Remember that there will always be some kind of broadcast radio service on the air. Radio stations that have had their towers and buildings knocked down by tornadoes have been back on the air in a matter of hours. That is what is expected of them, and their engineers know how to do it.

They will be sending important information about relief efforts, weather conditions, food, water and medical services that you may need very badly.

I am going to start with the first requirement – a good AM radio. At the first thought, it seems like a good idea to buy a simple $9.98 transistor pocket radio and leave it at that, but there are some interesting problems to consider.

First, your ability to hear up-to-date information during a national emergency just may save your life. Are you going to depend on a radio that barely worked in the store it was sold in? Simply put, you need an extremely dependable radio.

Second, your little cheap radio always sounds great listening to that strong local station when you buy it, but the station you need to hear may be distant and weak or covered by static.

Third, during the disaster, are you going to run down to the local store and buy a fresh battery? Hell no. You need a long-life renewable power source.

There are several solutions to the problem. Let's call them the simplest, the cheapest, and the best.

THE SIMPLEST SOLUTION

The simplest solution is a quality portable radio. Buy only one kind – Panasonic. Any model in the $50 to $100 price range will do which used "D" batteries, the common large flashlight battery.

Why Panasonic? I am in no way connected with Panasonic, but I have had considerable experience with the various brands of portable radios, and many thousands of dollars worth of laboratory electronic equipment to test them on. Other brands may be as good, but why take a chance?

When you buy your radio, ask for one that does not have a tape player or recorder in it. See that it has a button to turn on the dial lamp, and make DAMN SURE the store can get you the 12 V DC battery adapter so you can operate your radio from a car battery.

I am not giving model numbers, since models are changing constantly. Most changes are only external for sales appeal.

THE CHEAPEST SOLUTION

Surprisingly, you can often get a better radio for much less money, if you can use tools and do a little thinking.

The modern automobile radio is almost perfect. It is extremely rugged, uses 12-V DC, very sensitive, and uses an omnidirectional antenna.

Portable radios, including Panasonic, use a loop-type antenna for AM reception. The pull-up whip is only for FM. The reception of this type of radio is often very directional. Thus, the station that you need to hear just may be in the radio's null spot! You can waste a lot of time turning your radio trying to pull a signal in.

The whip or mast type of antenna used on the car radio works much better. It picks up stations from every direction, plus the whip is much more sensitive to weak signals than the loop. Your car radio also has special noise eliminating circuits in it to remove some of the static.

Picking your car radio takes some judgment. Follow these guidelines:

1. Pick an AM/FM from a late model, if you can.
2. DO NOT get one with an eight-track player in it.
3. DO NOT get one with tubes in it. Some special tubes made for car radios are not available ANYWHERE!
4. Use the original speaker if the radio is AM only. Many transistor radios use oddball impedance speaker.
5. Take the original electrical plugs; it will make your wiring neater and easier.
6. Simply use a piece of wire for an antenna or buy a new one. DO NOT try to salvage the original one. That heavy-looking cable to the antenna is actually very delicate.
7. Make the seller test the radio before you buy it.

Additional Note: If you own one of those God-awful mistakes from Detroit that has the "antenna" in the wind shield, put a standard car radio antenna on your fender and connect it to your radio. You will be absolutely amazed at how much better your radio will work.

Now let's get that prize of yours working.

First, you need power. Buy a good 12-volt auto battery and small charger. DO NOT get some junker from the trash pile of a gas station. A good dependable bowels are moved or the pain abated.

Apply *Rheumatic Liniment* warmed, with a flannel dipped in it, to subdue pain in the abdomen.

BLISTERED FEET.—Before and after walking, wash the feet well in a solution of Sal Ammoniac—half an ounce in two quarts of water. Let not the stocking be wrinkled, or much mended, when you walk. Easy boots and shoes should be worn, and very smooth next to the sole of the foot. ——Or, the best remedy for this is to rub the feet, when going to bed, with spirits mixed with tallow, dropped from a lighted candle into the palms of the hand.

BUG POISON.—The spirit of tar is a powerful remedy, applied by means of a brush; chloride of lime is a very good wash.—Bugs have become so general a nuisance, much care is necessary to get rid of them. Bedsteads should be taken to pieces at the beginning of the year, and each part washed with a strong solution of corrosive sublimate. The crevices or cracks should be stopped up with putty, then the joints and crevices painted with white lead, to be well dried before the bed is put together. Bugs do not like paint, it is too cold for them. If the walls are infested, the paper should be removed, and the walls washed with the corrosive sublimate, (stopping all cracks in the walls with plaster of Paris.) The floor in inveterate cases, may be painted all round the skirting-board to the extent of four inches. As the corrosive sublimate is a strong poison, the bottle containing it should be marked, and a caution given to those who apply it.

Coal oil, or naptha, is said to be a sure destroyer of bed-bugs. Apply plentifully, with a small brush or feather, to all places where they congregate. The cure is effectual and permanent. Gilt frames, chandeliers, &c., rubbed slightly over with coal oil, will not be disturbed by flies.

CANCER.—A cancer is a hard indolent tumour, usually seated in some of the glands, as the arm-pits, eye, nose, lips, tongue, womb, and the female breast; the two last are most subject to it. It affects the aged more than the young, and may exist for years. It commences with a small hard tumour, increasing slowly, and attended with

battery can be used for much more than this radio, IF IT WORKS!

Build for your battery a nice wooden box with a cover and few vent holes. Place it in a cool, NOT COLD, well-ventilated place and run some heavy wires (No. 12 to 14) back to your radio. Always connect the charger directly to the battery. Use a hydrometer to check the condition of the cells and charge according to its readings. Use only distilled water to top off the cells and do not over-fill. Keep the terminals greased on the outside to prevent corrosion.

If your house has metal siding, mount the antenna outside of a window. If you're in a standard frame building, mount the antenna on the box that holds the radio.

Your radio will have two power leads. One operates the radio; the other the dial light. Put a little switch in the light lead so it will only draw power when you need the light. Make sure that the lamp and the radio power leads have fuses in them (two amps is normal). This could save you a lot of burned up wiring or a fire.

If your radio has only one speaker wire, the other terminal of the speaker connects to the case of the radio, as does the negative wire from the battery.

If you want your radio to be really HI-FI, mount your speaker(s) in a baffle.

Build a wooden box of about three cubic feet volume. Any firm wood, plywood, or particle board will do. IMPORTANT: Line the inside of the box (baffle is the proper term) with fiberglass insulation – glass side out. Just glue the paper backing to the wood. This won't sound as good as $200 stereo system speaker, but it will sound one hell of a lot better than a bare speaker lying on a shelf.

Do the above with a good quality AM/FM stereo car radio, and you will be amazed at the job it will do. It will work better than any of the cheap three-piece stereo radios that you would normally buy. Plus, it will operate for many, many days off its auto battery during a power failure.

THE BEST SOLUTION

The auto radio is a hard one to beat. The only thing that would really be better is a professional communications receiver.

This is what used to be called a short-wave radio. There is much more to radio than just broadcast and CB. If you really want to know what is going on in the world and listen in on amateur (ham) emergency messages, this is the way to do it.

IMPORTANT NOTE: Almost all amateur, military, marine and government communications are by two modes – teletype and voice by single side band (SSB). NO ONE uses AM except international broadcast stations. (And their broadcasts are, with few exceptions, mostly propaganda.) The value of your receiver depends on how well it will receive SSB voice transmissions.

The old short-wave sets were built before SSB became common, and the cheap, so-called multi-band portable radios, do not have the circuits called BFO's or product detectors to receive SSB. Nor are the dials designed for the delicate tuning often required.

Because of these problems, the design of the modern radio is quite different than those of years gone by.

Whatever you do, do not try to use or convert any old surplus military radio equipment. It is simply not worth the time unless you are a well-trained electronic technician with a good shop. Military equipment often uses tubes or other parts that look like they were made on Mars. Spares are difficult to find. The radios usually require 24 volts DC for power or worse, 400 cycle, three-phase AC.

The design of most surplus is obsolete—that's why it is surplus! Yes, I know it's waterproof and its paint job matches your tank; but do you really want a 30-year-old weirdo radio?

If you have the money, buy a DRAKE Model SSR-1 receiver at $350. It covers from the bottom of the broadcast band, ½ MHZ, to-way past the CB band, 30 MHZ and all the short-wave bands and ham bands in between. An excellent receiver for AM, SSB and code, it will operate from 12 volts and is made in the U.S.A.

There are several other excellent imported communications receivers available. Seek out the opinion of a couple of local amateurs to help you pick it out. I DO NOT recommend the Radio Shack equipment.

Short wave listening is a very complex subject that I can not cover here. This is where world radio communications is carried out, and whenever there is any kind of disaster or emergency, the amateurs will be on the air handling messages to and from the area.

In one serious flood in my area, teen-age hams using their own equipment provided the U.S. Army with most of its communications for two weeks!

In the meantime, you CB people will be amazed to hear the job a professional receiver will do on the CB band; far better than any CB set you have ever heard.

Remember, if the world turns into a total mess, you can always cobble up some kind of transmitter for communications, BUT ONLY IF YOU HAVE A PROFESSIONAL RECEIVER TO START WITH!

acute shooting pains; sooner or later ulceration sets in. The discharge is so acrid as to inflame the part with which it comes in contact. The place where cancer occurs assumes a purplish appearance previous to its ulceration. Ulceration gives ease for a time, but the cancer penetrates deeper, and spreads wider, corrupting the stream of life, and reducing to the greatest debility, and often terminating in death.

To Cure, remove debility, and improve the general health. Regulate the bowels, and give an emetic. Give a vapour bath made of bitter herbs, as camomile, hops, catnep, tansy, &c. and boiling water and vinegar. Occasionally rub the whole surface of the body with the following liniment;—cayenne, a tea-spoonful; salt, two table-spoonfuls; pour upon them half a pint of boiling water; infuse three hours, and then add half a pint of boiling water; infuse an hour longer, stirring occasionally. Steaming with the bitter herbs, combined as above, allays the pain, swelling and inflammation. The following pills will be of much use; blood-root, one and a half drachms; extract of dandelion, three drachms; lobelia seed, one drachm; cayenne, one drachm; senna, in powder, one drachm; add three drops of oil of mint, and form into pills. These pills will be found very efficacious in the cure of jaundice, and liver complaints.

Citric Acid will relieve the pain of cancers. Dr. Brandini, of Florence, had a patient, aged 71, affected with cancer on the tongue. An operation could not be made, for the affection was too extensive, investing the base, the sub-lingual, and the sub-maxillary glands. In the midst of his pain, the poor man asked for a lemon. It abated the pain; and the next day it gave him still greater relief. This led the doctor to try *Citric Acid*; four grains of the acid, in one ounce of water; and this, as a gargle, entirely carried off the pain, and reduced the swelling of the tongue very much. The doctor tried the same remedy on a female with an ulcerous cancer on the breast, deemed incurable. Her torments were so great, that neither she, nor the other patients could get any rest. He applied a pledget of lint soaked in the above solution, and the relief was instantaneous. It was repeated with the same success. Thus Citric Acid promises to be a great boon to mankind.—Citric Acid is prepared from lemons.

Externally apply the following;—Simmer cicuta leaves till they are soft, then mix them with slippery elm bark, to form a poultice; apply morn and night. It is valuable.—Or apply the *Irritating Plaster*, for a continual

Survive Through a Home Business

By Kurt Saxon

As our system slows down, unemployment will soar. Revenue for welfare will dwindle due to the scarcity of taxpayers and the recipients will starve. Less taxes will bankrupt the Social Security system and the elderly will starve. Industries will shut down and labor unions will go broke for lack of dues paying members. Cities will become shooting galleries and small towns will become garrisoned city-states.

As bad as this might seem, now, it has to be so you might as well prepare to ride it out.

Your only real hope in the near future is a home business. This will not only give you independence, but it will give you the confidence that destroys fear.

A home business has many advantages over being employed by others. First, you don't have to commute to work. Also, being around the home all day provides the best security as you are usually on hand to defend your home and loved ones.

Another big advantage is that a home business is almost tax-free. Everything connected with your business is deductible. Rent, utilities, your car or truck, gas and just about anything you buy and can claim as a business necessity. You can also deduct any business losses.

The factory or office worker can't deduct his rent, car, gas or any transportation expenses unless he's a traveling salesman or something similar. He must pay more for clothing so as to be presentable to the public and his fellow workers. Working for others is very expensive. Even union dues aren't deductible.

So if you work for others, you are a virtual slave. A big slice of your earnings is taken from your paycheck each payday. You never see it. You can't use it, invest it or even put it in the bank to draw interest until April 15.

Many Americans take in millions each year and pay no taxes at all. They know all the loopholes and declare only what they please. The working stiff, however, has no loopholes to speak of and he can't even cheat on his taxes. At least not where his main earned income is concerned.

Another good reason to start a home business is that you can't be fired or laid off. In that sense, it's depression-proof. Of course, if you fail in your business, you've created your own depression.

For this reason, you must practice a lot of caution and foresight. Don't quit your job until you are making as much or more from your home business as from your job.

Part of the beauty of starting a home business is that you can build it up while you are holding a regular job. There is a lot less risk in starting a home business than if you started a contracting or service business where you had to work full-time.

At this point I want to advise you against the home business come-ons in such magazines as POPULAR MECHANICS. Everyone has seen their ads for home business or to be worked out of the home, such as upholstering, locksmithing, carpet cleaning, TV repair, electrical appliance repair, etc.

These ads are all sucker bait.

First, they are written by expert ad copywriters to appeal to the ignorant and unskilled. They have their testimonials, usually from the one-out-of-a-thousand who did succeed with their business.

They know very well that most of their customers will not get a return on their investment. A person with the skill and discipline to really apply himself to such a business, would be a success at most anything and would have no need for their course.

And in most cases, it is simply a correspondence course. Such courses are so expensive, from $200 to $800, the ad writers leave out the price of the course. You have to send away for even more of their advertising.

In most cases, if your community can support the business they advertise, discharge must be kept up, as the patient is able to bear it. The douch bath has been recommended, and doubtless it has had a good effect in many cases. The following applications are useful ;—

Cayenne and lobelia seed, equal quantities powdered ; meadow-fern and balm of Gilead buds, of each 3 ozs. (these two steeped in spirits for five or six days, and made into ointment, with lard sufficient.) Unite the whole as a paste, and apply to the cancer, covering with a cloth. When the plaster is taken off wash with soap-suds.—Or burn a quantity of red oak bark to ashes, and make into lye. Boil the lye till it becomes as thick as honey. Then apply constantly. Such preparations, by their stimulating and relaxing properties, excite a preternatural discharge, or cause a sloughing of the ulcer, and thus remove or lessen it. Use one of these ointments principally, the *Black Salve* occasionally, and after much discharge, dress with an emollient ointment. This treatment has effected numerous cures. (See Black Salve.)

A decoction of narrow-leaved dock-root has been found to produce rare effects. Saturated cloths with the same may also be applied. Or the root may be powdered, and made into an ointment with lobelia seeds powdered.

CANCER.—Use the cold bath. —This has cured many.—A bleeding cancer was cured by drinking twice a day a quarter of a pint of the juice of clivers, or goose grass, and covering the wound with the bruised leaves. Another by the following receipt :—

Take half a pint of small beer. When it boils, dissolve in it an ounce and a half of bees' wax : then put in an ounce of hog's lard and boil them together. When it is cold pour the beer from it, and apply it spread on white leather. Renew it every other day. It brings out great blotches, which are to be washed with sal prunello dissolved in warm water.

If it be not broken, apply a piece of sheet lead beat very thin, and pricked full of pin holes, for days or weeks to the breast. Purges should be added every third or fourth day.—Or, rub the whole breast morning and evening with spirits of hartshorn mixed with oil. Or, keep it continually moist with honey.

CANCER PLASTER.—White oak-bark, 4 oz. ; bruise it well, and add urine sufficient to cover it. Infuse four days, boil it till it becomes as thick as treacle. Add 2 ozs. of honey, and 2 ozs. of strained turpentine gum. To make this plaster caustic, add 2 drachms of white vitriol. Spread on soft leather, or linen.—It may be applied to all kinds of ulcers, white swellings. For cancers it is invaluable.

there is already an established business in that line. But they avoid such considerations. Their aim is to make you believe that an amateur such as yourself can successfully compete with established professionals. This is unrealistic at best.

But you might ask, if their deals are really rip-offs, how do they stay in business? Well, you take any ad, full page, costing several thousand dollars for each insertion, run month after month, year after year. They couldn't afford these ads if they weren't selling a lot of those courses.

But where are their graduates? There should be a locksmith on every corner and a TV repairman in every second house on the block.

The truth is that most correspondence schoolers drop the courses after a couple of lessons. And the schools couldn't pay for those ads if they didn't threaten to prosecute the student for payment for part or all of the failed course.

Another thing wrong with the majority of such courses is their specialization. The course and the equipment you get is worthless for any other application.

Also, for a small tuition fee, you can take night high-school or college shop courses on many of the skills these correspondence schools offer.

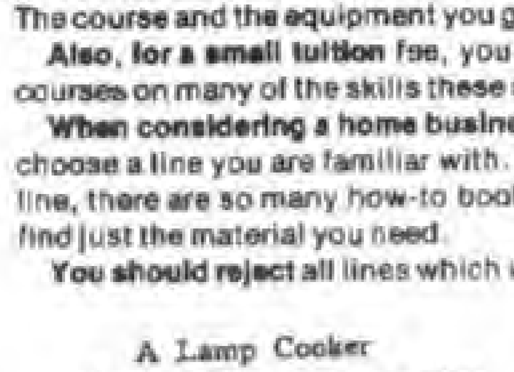
When considering a home business, instead of some exotic line, you should choose a line you are familiar with. Even if you are not so familiar with a certain line, there are so many how-to books on the market that you should be able to find just the material you need.

You should reject all lines which would not be essential after the collapse.

A Lamp Cooker

From Popular Mechanix 1919

An ordinary circular-wick kerosene lamp produces enough heat to do considerable cooking, provided the heat is properly utilized. A simple and practicable method of converting such a lamp into a cooker is as follows: Saw a hole, 12 in. square, in the top of a small table, or packing box of about the same height as a table. Cover this with a piece of sheet metal, having a 4-in. hole in the center. Place a 6-in. flowerpot over the hole in the metal, and plug up the hole in the bottom of the pot with fire clay or plaster of Paris. Vegetables in jars may be set around the flowerpot to cook slowly and a roast in a pan on top of it. A wooden box, or metal pail, large enough to cover the arrangement, should be placed over it. Air holes should be provided in the lower box and in the cover.



The Lamp Cooker will Prepare Meats and Vegetables Satisfactorily, and Is Useful for the Camper and in Emergencies

To operate the device light the lamp and when it is burning brightly, place it under the table, elevating it so that the top of the chimney is in the center and barely within the rim of the flowerpot. Use little water in the vegetables and keep the caps loosely on the jars. The roast, if well buttered, will brown nicely, and while the cooking will require considerably more time than it would in a range, the results will be as good, if not superior. The natural juices are preserved by the slow cooking at comparatively low temperature. The cover may be lifted to turn the meat occasionally. This device will appeal to campers, summer cottagers, and others.

Homemade Electric Plant from Old Auto-Truck Chassis

From Popular Mechanics 1933

Owners of a filling station and general repair shop, where electricity was used extensively, found that the cost of the current was too high and installed their own generating plant, the main part of which was an old auto truck. They set the truck chassis on blocks and fastened a multiple V-pulley on the driveshaft. Just above this, a 20-amp. generator was mounted on the frame and was belted to the driveshaft pulley by means of five V-belts, which decreased belt slippage to a minimum. The motor was altered to run on natural gas by enlarging the air vent in the carburetor. With this plant, electricity was produced at a cost of about one cent per kilowatt hour.

CARMINATIVES.—Rind of Seville oranges, 3 drachms; fresh lemon peel, 2 drachms; ginger, in powder, ½ drachm; boiling water, 8 ozs. Infuse 2 hours, and strain. Then take of the above, ½ oz.; spirit of peppermint, ½ drachm; spirit of lavender, ½ drachm.

Antiflatulant Mixture.—Oil of aniseeds, 10 drops; refined sugar, 1 drachm. Beat up together, and add, tincture of ginger, 2 drachms; peppermint water, 6 ozs. Mix; three tablespoonfuls when needful.

Another.—Assafœtida, 6 grains; rhubarb, 4 grains; oil of aniseeds, 5 drops. Make two pills, and take every five or six hours.

CARMINATIVE DROPS; for Expelling Wind.—Angelica, 2 ounces; lady's slipper, 1 ounce; sweet flag, ½ ounce; anise, 1 ounce; fennel seed, ½ ounce; catnep flowers, 1 ounce; motherwort, 1 ounce; pleurisy root, 2 ounces. Infuse in a pint of spirits of wine for three or four days, oft shaking, keeping it in a warm place; then add a pint of water, and a tablespoonful of tincture of cayenne. Excellent in flatulency, colic, nervous affections, promoting perspiration, and refreshing sleep.

Another Receipt.—Anise, dill, fennel seed, of each ½ ounce; catnep flowers, and motherwort, of each, 1 ounce; pleurisy root, 4 ounces. Infuse in brandy for 22 hours, and then strain; to children, give from five to fifty drops; and to adults, from one to four teaspoonfuls, every three or four hours.—It eases pain, produces perspiration and sleep, removes flatulency, colic, and is an excellent nervine.

CARMINATIVE PURGATIVE.—Tincture of senna, 1 oz.; powder of aloes, 10 grains; peppermint water, 3 ozs.; syrup of ginger, 1 oz. Two table-spoonfuls for a dose, repeated in three hours if necessary.

CHARCOAL, useful properties of.—All sorts of glass vessels and other utensils may be purified from bad smells by rincing them out with charcoal powder, after the grossest impurities have been scoured off with sand and potash. Rubbing the teeth, and washing out the mouth with charcoal powder will render the teeth beautifully white, and the breath perfectly sweet.

CHARCOAL MEDICINE.—It is much used in Mexico, and in South America, where few drugs are procurable save those "simples" which the ingenuity and experience of the *Indian Herbalists* have devised. Freshly-burnt Charcoal, reduced to powder and given in water, is in great repute. It immedi-

Build a Pit Cabin

by Ron Lank

The nuclear war which the Pentagon expects to devastate North America before the end of this century will make a lot of changes in our lifestyles. One which you may wish to make and live in is a pit cabin.

Instead of building your log cabin to the usual height, build the walls on easily dug, well drained soil to a height of only three or four feet. This will save you the labor and back breaking risk of lifting logs over your head. Also, when you put the roof on you can stand on the floor and work at an easily accessible height, so you can do a good job. Install the door with the idea that you will later want to extend it downward. If the ground has a slope, put the door on the downhill side.

After the original low wall cabin has been completed you can then lower the floor by digging.

In selecting your logs, cedar should be selected as the bottom layer, in contact with the ground. Poplar or whatever else is available may be used for the other layers and for the roof. The reason I'm suggesting the use of poplar is the fact that there is so much of it around. Spruce is also excellent.

Poplar, when fresh cut, is fairly soft and easy to work. After it has dried it becomes very hard and serviceable.

In using poplar, leave most of the bark on to discourage rot. Peel off about a twenty degree strip of bark off each log from the side toward the inside of your cabin. This will control the shrinkage of the bark.

After you have the basement dug out to the size you want you can line it with cedar logs to keep the dampness from the soil out. Cedar should be used because it will be the most rot resistant wood available.

Besides the ease and safety in building, a pit cabin has other advantages. When the winter blizzards slam against the sides, you're going to be hard to get at even if one should find any openings where you didn't jam enough moss, clay and stuff between the logs. It will take less firewood and other stuff piled against those low walls to double the insulation than on a conventional structure.

With the cold wind finding it so difficult to get in, and the heat from your fireplace finding it so difficult to get out, your new home will be just plain cozy.

If somebody doesn't like you, attacking you in your roofed over foxhole can be ridiculously hazardous to his health. You may wish to camouflage your pit cabin by adding rocks to the outside insulation, leaving only a few gun slits here and there to help air the place.

Just how difficult and hazardous a pit cabin can be to attack was proven to the Mounties when they attacked Albert Johnson, The Mad Trapper, in his pit cabin in the Yukon. They nearly got him when they threw that bundle of dynamite onto the roof. There's nothing like a roof built of a row or two of good stout logs to complicate that sort of thing.

From Popular Mechanics 1932

Sheet Metal Clamped in Vise Is Bent by Means of Wooden Block and Mallet

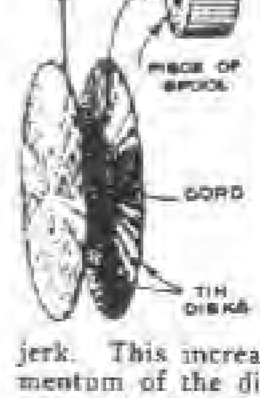
Shaping Sheet Metal without the Use of a Bending Machine

To shape sheet metal without the use of a bending machine, place a suitable length of angle iron on each side of the metal and clamp the assembly in a vise. The sheet metal can then be bent by holding a block of wood against it and striking the latter with a mallet.

Making and Using the "Bandilore"

An East Indian toy, known as a "bandilore," is made from a piece of spool, about ½ or ¾ in. thick, and two tin disks, about 4 in. in diameter.

The section of spool is tacked between the two disks, exactly in the center. Tie one end of a 3 or 4-ft. length of stout cord to the spool. The bandilore is operated by winding the cord around the spool, and holding the free end of the string in the hand. The toy is dropped and descends with great speed; just before the end of the cord is reached, the whole thing is given a quick upward jerk. This increases the speed and momentum of the disks so that the cord is wound in the opposite direction, and the bandilore climbs upward, the process being repeated as often as desired.



ately removes offensive odours from intestinal and renal discharges, and purifies the breath, it removes offensive exhalations from any part of the body, either given in water, or in the form of pills, made up in wheat flour, or gum mucilage. It removes pains about the right shoulder caused by obstructions of the liver. As an antacid, either or combined with rhubarb, and carbonate of soda, it speedily and permanently removes heartburn. Charcoal is a powerful antiseptic, removing, or checking decay, and must be very valuable in the incipient stages of consumption.

CHLORIDE OF LIME.—Scatter chloride of lime on a board in a stable to remove all kinds of flies, but more especially biting flies. Sprinkling beds of vegetables with even a weak solution, effectually preserves them from caterpillars, slugs, &c. A paste of one part powdered chloride of lime and one half-part of some fatty matter placed in a narrow band round the trunk of a tree, prevent insects from creeping up it. Even rats, mice, cockroaches, and crickets flee from it.

CHLORIDE OF LIME.—*It is* a great purifier. One pound requires three gallons of water; use the clear solution. To purify rooms, sprinkle on the floor; and if needful, on the bed-linen. Infected clothes should be dipped in it and wrung out, just before they are washed. It purifies night commodes, and water closets, &c.

COCKROACHES, to Destroy.—Mix bread crumbs, sugar, and corrosive sublimate, and place it near their haunts.—Or mix sugar, laudanum, and water together.—They are very fond of beer, which might be substituted for water.—Some persons have found a mixture of plaster of Paris, sugar, and oatmeal, effectual.——Powdered phosphorous, oatmeal, and sugar, form a sure remedy.

CREAM CHEESE.—Put five quarts of the last milking of a cow, called "*strippings*," into a pan with 2 spoonfuls of rennet. When the curd is come, strike it down with the skimmer to break it. Let it stand 2 hours, spread a cheese cloth on a sieve and drain upon it; break the curd a little with your hand; put it into a vat with a 2 lb. weight upon it. After standing 12 hours bind a fillet round. Turn every day till dry; cover with green leaves, and let them gradually ripen on a pewter plate.

EGG PICKLE.—Boil from two to three dozen fresh eggs quite hard; then set a sufficient quantity of good vinegar over the fire, ginger, white pepper, mustard seed, and a clove or two of garlic. Having placed the eggs

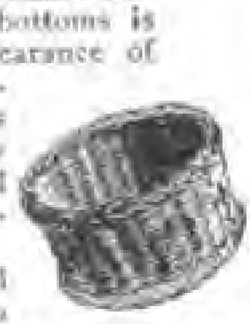
Reed Furniture

By Chas. M. Miller

From Popular Mechanics 1915

A Reed Basket

INASMUCH as there is a great demand for reed furniture and since good weavers are comparatively few in number, it would be well to learn the process of reed weaving. The weaving operations can be learned much better through the construction of some small article, such as a basket or jardinère cover. The center is the most difficult part of the basket making, and it is best to begin with wood bottoms, as the whole basket can be kept in a much better form due to the stiffness furnished by such a bottom. It is also an approach to the reed furniture which is woven on framework. The objectionable feature of the wood bottoms is the unfinished appearance of the wood edge showing through, but this can be overcome by the use of the roll shown in the illustration.



While the wood bottoms have been used for this class of work for a number of years, the roll is new and is very popular with those who have seen and used it. The roll can be placed in many ways on different-shaped baskets, and other reed pieces, so that it is best to master this piece of work thoroughly before attempting the other, or larger, pieces that will be described later, in other articles.

The description is for a basket 5 in. in diameter and 3 in. high, as shown in the illustration. A disk of wood, ½ in. thick and 5 in. in diameter, is required. Basswood makes the best bottom, but pine, or cedar, will do. Cut a board about 6 in. square, and draw diagonal lines on it intersecting at the center, then draw a circle, 5 in. in diameter, as shown in Fig. 1; also another circle,

using the same center, 4¾ in. in diameter. Set compass points about ⅝ in. apart, and step off spaces on the inner circle to make 24 points. This will have to be tried out more than once, to get the spaces to come out evenly and just have the right number of points. Holes are bored with a ⅛-in. bit, just inside of the inner circle, back of the places marked by the compass points, as shown in Fig. 2. Cut the board on the outside circle with a coping, or turn, saw, to make the circle, as in Fig. 3. Do not saw out the circle before boring the holes, as otherwise the disk might split out in places.

The reeds placed vertically are called spokes, and the horizontal ones are the weavers. For the spokes, what is called a No. 4 reed is used. Do not wet the spokes before putting them through the wood. Allow the ends to project about 5½ in. below the bottom, as shown in Fig. 4. Place the bottom, with the spokes, in water, and soak them thoroughly, especially the part below the bottom. About 15 minutes of soaking will be sufficient to make them pliable enough to bend over at right angles. It will not injure the wood bottom to soak it with the reeds. As shown at A, Figs. 4 and 5, each spoke below the wood bottom is bent down and back of the two nearest spokes, B and C, then out between the third and fourth spokes, C and D, and so on. The last two spokes, Y and Z, Fig. 6, are forced under the spokes A and B, respectively. In this illustration the spoke Y is shown as it is being inserted under the spoke A. When this operation is completed, the bottom will have the appearance of a fireworks pinwheel.

Continue the bending of the spokes, in the same direction, up and across the thickness of the wood in front of three other spokes and behind the fourth, as shown in Fig. 7. This would not cover the edge of the wood entirely, and, for this reason, other short spokes must be inserted in front of each of the first ones before it is brought up without shells into broad mouthed jars, pour the vinegar, &c., over them. When cold tie them down. The pickle will be ready in a month. It forms a pretty garnish when cut in slices, and constitutes a piquant relish with cold meat.

EXTRACTS, to Make.—Take of the plant, root, or leaves you wish to make the extracts from, any quantity, add sufficient water, and boil them gradually, then pour off the water and add a second quantity; repeat the process until all the virtue is extracted, then mix the several decoctions, and evaporate at as low a temperature as possible, to the consistence of an extract. Extracts are better made in a water-bath, and in close vessels, and for some very delicate articles, the evaporation may be carried on at a very low temperature, in a vacuum, by surrounding the vessel with another containing sulphuric acid. Manufacturing druggists usually add to every seven pounds of extract, gum arabic, 4 ounces; alcohol, 1 ounce; olive oil, 1 ounce. This mixture gives the extract a gloss, and keeps it soft.

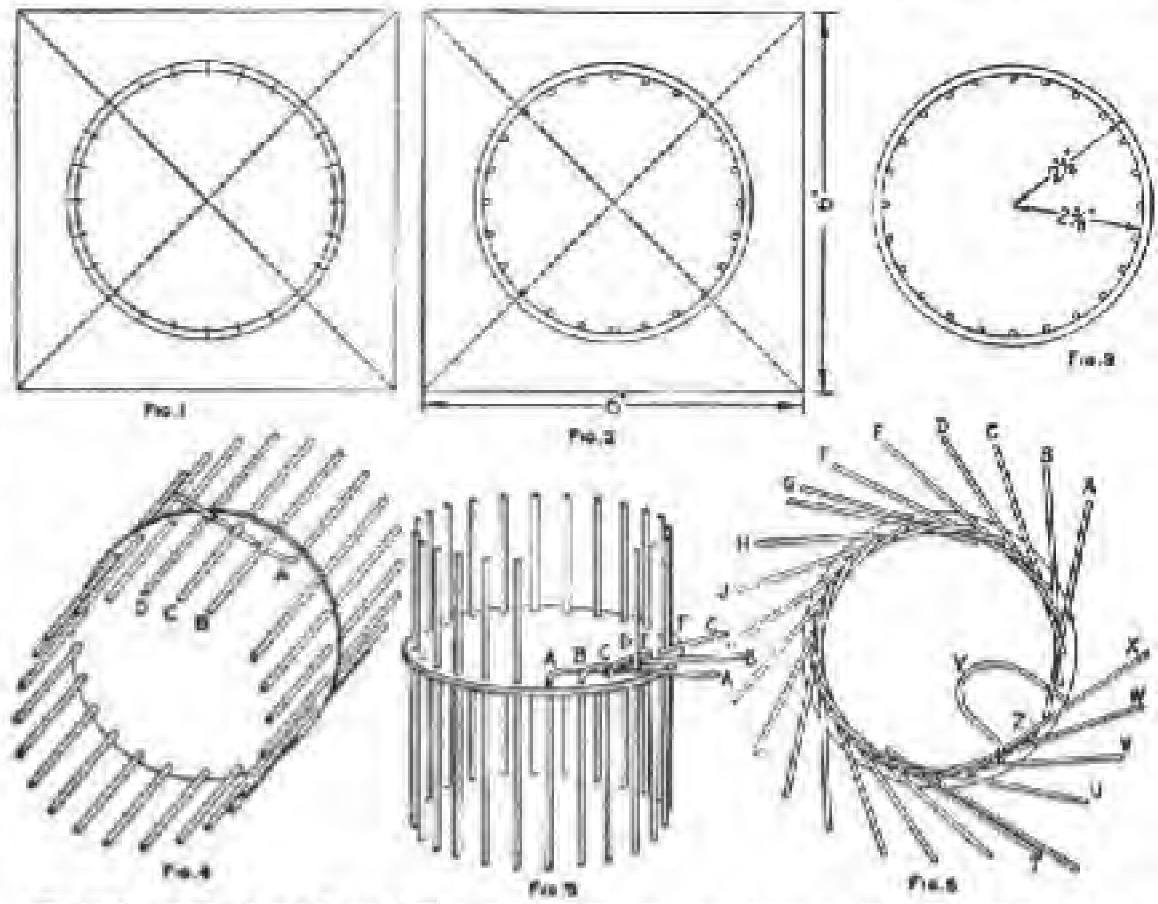
FEATHERS, to Clean.—Feathers may be cleansed from their animal oil by steeping them in lime water—1 lb. of lime to a gallon of water, stir well, and then pour the water from the lime.

To Cleanse Feathers from Dirt, make a strong lather of white soap and hot water. Put in the feathers and rub them for 5 minutes. Rinse in clean hot water.

FEATHERS TO CURL.—Heat them slightly before the fire, then stroke them with the back of a knife, and they will curl.

FEATHERS TO DYE.-Steep them a few hours in warm water.—*Blue* may be dyed by extract of indigo and boiling water. Simmer over the fire a few minutes.—*Green;* Verdigris and Verditer, 1 oz. each; and gum water; dip the feathers. Or mix the indigo liquor with Persian berry liquor.—*Lilac.* Use cudbear and hot water.—*Red.* Brazil wood, a little vermilion and alum, and vinegar; boil 30 minutes; and then dip the feathers.—*Yellow* by turmeric.—*Scarlet,* by cochineal, cream of tartar, and muriate of tin.—Ready prepared dyes can be purchased at the druggist's shops.

FRECKLES.—Take 1 oz. of lemon-juice, a quarter of a drachm of powdered borax, and half a drachm of sugar; mix, let them stand a few days in a glass bottle, then rub it on the hands and face occasionally.——Or, mix two-teaspoonfuls of muriatic acid with 2 ozs. of spirits of wine; and 1¾ pint of distilled water.——Or, 2 drs. of muriatic acid in 1 pint of water, and a



The Bottom is Cut from a Piece of Wood to Give Strength and to Avoid the Most Difficult Part of the Weaving; the Reeds are Attached to the Bottom and Their Lower Ends Bent as Shown

across the edge of the wood. These supplementary spokes should be about 4 in. long. The manner of inserting these spokes before making the bend is shown at G and T, Fig. 6. The double spokes must be pressed down flat, when brought up in place, without riding one on the other. If the ends are too long and interfere with the next pair, they can be cut off a little with a flat chisel, or knife, being careful not to make them too short, or the pieces will not stay in place. If there is still an open space, an extra, short spoke can be inserted to crowd the pieces together and fill up the space.

When the roll is completed, insert three weavers, of No. 3 reed that has been soaked about 15 minutes, placing them between the spokes A and B, B and C, and C and D, as shown in Fig. 8. Pass weaver L in front of the spokes B and C, then back of D and out between D and E. Weaver M is passed in front of C and D, back of E and out in front of E and F. These operations are clearly shown in Fig. 9. The weaver N is placed in front of D and E, back of F and then in front of G and H. At this point the weaver L is used again. The weaver farthest behind each time is brought in front of the two spokes nearest to it, then behind the third and out in front of the next two spokes. Do not try to use weavers longer than 8 ft., which is about half the length of a reed. When a weaver is used up, press it back to the side a little, push in a new reed about 1½ in., and continue the weaving. This is clearly shown in Fig. 10. This weaving is known as the triple weave, which cinches down well and holds tightly. The first round should be carefully worked, so as to get the ends of the roll properly pressed down flat in place. Each throw of the weaver should be well pressed down.

The break-down-tight border is used for the finish at the top. The first operation in making this border is shown in Fig. 11. The spoke A is bent over back of spoke B and out between spokes B and C. The spoke B is bent over back of the spoke C and out between C and D, and so on, until the spoke E is turned down. Then take the end of the spoke A, Fig. 12, and lay it over B, C, D, and E, in front of F, back of G, and out between G and H. The end of spoke F is then brought down, also between G and H, but back of the end of A. The end of B takes a similar leap, passes behind H and out between H and J; then G is brought down behind the end of B, in the same manner as F was brought down back of A. The last four or five spokes are the most difficult to handle, as they must be forced through the first ones to correspond with those already in place. It is best not to pull the ends of A, B, C, and D down too tightly at first, keeping in mind that the last ones must be inserted under the first ones. The last standing spokes are represented by the full and shaded lines.

teaspoonful of spirits of lavender. Apply with a camel hair pencil, or linen.——Or, horse-radish steeped in sour milk for 12 hours, and a drop or two of tincture of myrrh. Wash two or three times per day.

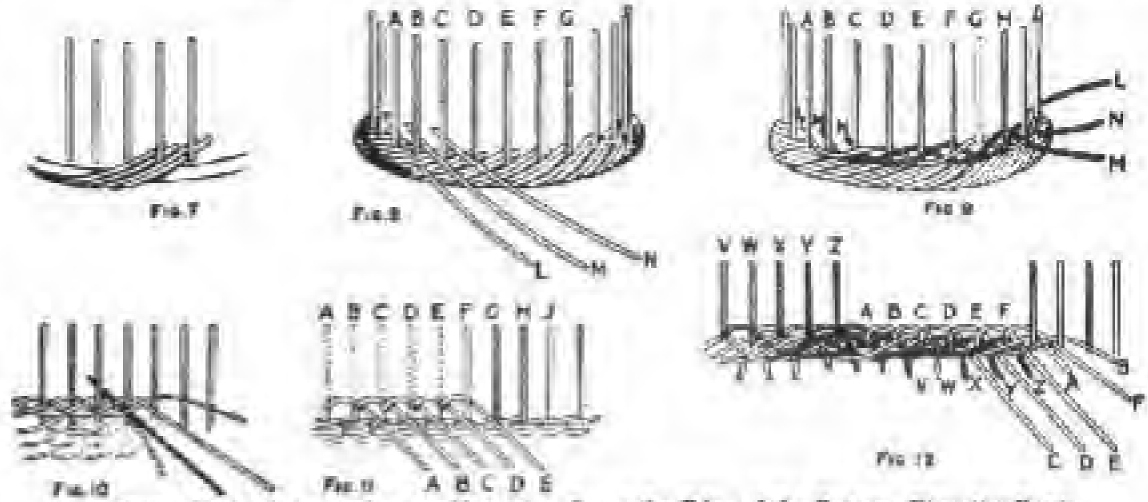
FREEZING MIXTURES.—If ice cannot be obtained, water may be cooled to the freezing point by the following mixtures: — sal ammoniac, 5 parts; nitre, 5 parts; glauber salts, 8 parts; water, 16 parts.——Or, nitrate of ammonia, 1 part; carbonate of soda, 1 part; water, 1 part.——Or mix 1 part of muriate of ammonia, or sal-ammoniac powder, with 2 parts of nitrate of potash, or saltpetre:—this forms *one powder*. The powder to be mixed with it is formed of barilla, or the best Scotch soda, powdered. This must be kept in a cool place, well corked, as must the first powder. For use put an equal quantity of these two powders into the ice-pail, and pour on them as much cold spring water as will dissolve them.

FRUIT SALT.—This excellent article is composed of 2 ozs. of Epsom Salts, 2 ozs. of Cream of Tartar, 2½ ozs. of Carbonate of Soda, 2½ ozs. of Tartaric Acid, 4 ozs. of finely powdered sugar. Mix rapidly altogether adding a small quantity of Bromide of Potass. Put into a dry bottle, *well corked*. Take a good tea-spoonful in a tumbler glass of water occasionally. It is excellent for quickly moving the bowels, pain in the stomach, &c.

FUEL, Cheap.—One bushel of small coal or saw-dust, or both mixed together, 2 bushels of sand, 1½ bushels of clay, made into balls, or bricks, and allowed to set firmly, will supply an excellent fuel, and effect a great saving in coals.

FUEL, to Save.—Take 4 lbs. of chalk in lumps, not above ½ lb. each. Make a clear fire of coal, and place the lumps of chalk in the grate, as coal is laid. The chalk becomes red hot, so as to be scarcely distinguishable from burning cinders. A few ashes or small coal thrown lightly on from time to time, will keep up a clear bright fire all day. The same chalk may be used 3 or 4 days, when it becomes lime, and manure for gardens or allotments, or for whitewashing. Half-a-peck of coal used thus with chalk, will give a capital fire for 14 hours. The saving in coal is 1½. In grates the chalk should be kept behind, and coals in front; because chalk will not burn unless in has coal or heat on all sides of it.

FULMINATING SILVER.—Put into a small-necked bottle, resting on a little sand, one part of fine silver filings and 3 parts of nitro-muriatic-acid. When the silver is dissolved, pour the solution into a glass, add 5



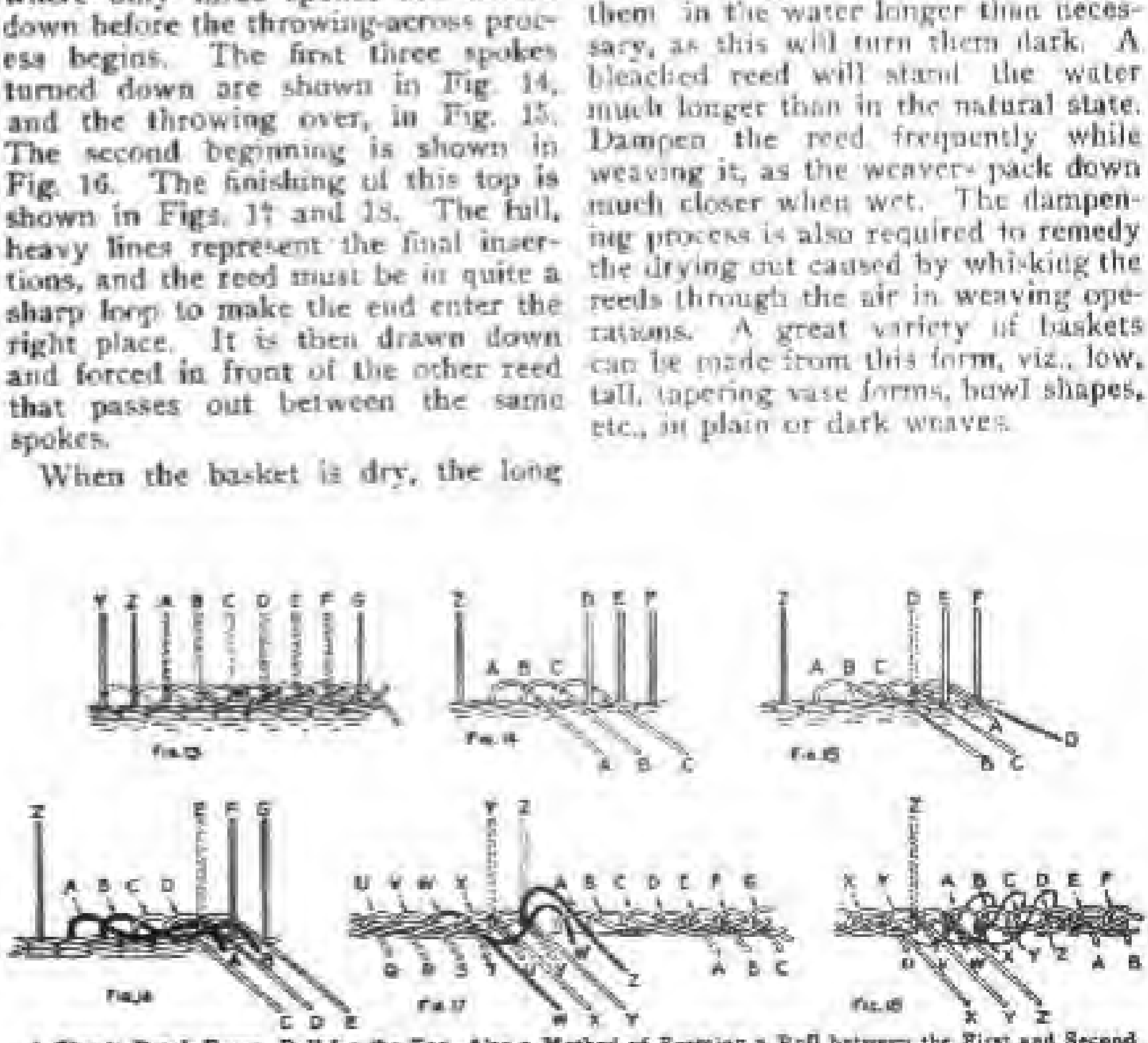
The Lower Ends of the Spokes are Turned in Cover the Edge of the Bottom. Then the Reeds are Woven into the Upright Spokes to the Right Height, Where They are Broken Down and Woven into a Top Border

If the roll illustrated in Figs. 11 and 12 is too difficult, a simple break-down can be used, such as shown in Fig. 13. To make this finish, spoke A is turned back of spoke B, in front of spoke C and back of spoke D, but not out again. Spoke B is bent back of C, in front of D, and back of E. The others are turned down the same way. The manner in which the two last spokes are turned down and inserted is shown by the double dotted lines.

The remainder of the illustrations show the method of forming a roll between the first and second spokes, where only three spokes are turned down before the throwing-across process begins. The first three spokes turned down are shown in Fig. 14, and the throwing over, in Fig. 15. The second beginning is shown in Fig. 16. The finishing of this top is shown in Figs. 17 and 18. The full, heavy lines represent the final insertions, and the reed must be in quite a sharp loop to make the end enter the right place. It is then drawn down and forced in front of the other reed that passes out between the same spokes.

When the basket is dry, the long ends can be cut off close up with a knife, being careful not to cut a weaver. If there are hairy fibers sticking out they can be singed off over a gas, or other, flame that will not smut. If it requires bleaching, brush some chloride of lime, mixed in a little water, over the reeds and set in the sunlight for a short time. It is better to leave the finish a little dark rather than use too much bleaching, as the latter will give an objectionable whitish appearance that looks like a poor job of painting.

In working the reeds, do not leave them in the water longer than necessary, as this will turn them dark. A bleached reed will stand the water much longer than in the natural state. Dampen the reed frequently while weaving it, as the weavers pack down much closer when wet. The dampening process is also required to remedy the drying out caused by whisking the reeds through the air in weaving operations. A great variety of baskets can be made from this form, viz., low, tall, tapering vase forms, bowl shapes, etc., in plain or dark weaves.



A Simple Break-Down Roll for the Top. Also a Method of Forming a Roll between the First and Second Spokes Where Only Three Spokes are Turned Down Before the Throwing-Across Process Begins times the quantity of water, then take spirit of sal-ammoniac, and pour it into the solution drop by drop, until the silver is precipitated to the bottom; decant the clear liquor, and wash it several times in warm waters, dry and place it on paper, to absorb the moisture. If a grain of this powder is put into an iron spoon, and exposed to the flame of a candle, it will explode with a loud report. The crackers are made with this powder, a small quantity being placed in a bit of paper with a pea and a bit of sand twisted up.

FURNITURE CREAM.— Linseed oil, 1 pint; spirits of wine, 2 ozs.; vinegar, 1 oz.; butter of antimony ½ oz.

FURNITURE POLISH.— The cheapest is a mixture of linseed oil and turpentine, laid on in a thin coat, rubbed off with a soft cloth and polished.

Furniture in constant use is greatly improved by washing with vinegar and water, and afterwards applying cold drawn linseed oil, rubbing it very much. It should be rubbed again in a day or two afterwards.

Or, linseed oil, 1 pint; spirits of wine, ½ gill. Mix well. Apply with a linen rag. Rub dry with a soft cotton cloth. Rub last and hard with a piece of old silk. In time it will have a most beautiful gloss. Or,

Linseed oil, bees wax scraped into, and gradually dissolved in turpentine, to the thickness of cream. Apply as above and rub well.

Or, 1 pint of linseed oil, 1 oz. of finely powdered rose pink, 1 oz. of shellac; beat well 1 oz. of alkanet root, and add it to the other. Keep the vessel in a warm place for a week, stirring now and then. This is excellent for darkening new wood, and removing marks, &c. Apply, and rub as before. Chamois leather is the best to rub with.

FURNITURE POLISH.— Spirits of wine, 1 pint; gum shellac, and gum lac, of each ½ an oz.; gum sandarac, ½ oz. Melt with very gentle heat, frequently shaking the bottle. Double or treble a piece of cloth; put a little polish upon it; cover that with a piece of soft linen rag lightly touched with cold-drawn linseed oil. Rub the furniture or wood in a circular direction. Afterwards, rub in the same way spirits of wine, with a little of the polish added to it; and a very brilliant polish will be produced. Some furniture requires previous scraping with fine glass paper, on account of having been polished with wax.

Or, linseed oil, 1 pint; treacle, 8 ozs.; add a glass of gin; stir well; apply with a rag; rub till dry, and it will produce a splendid gloss.

Woven Reed Furniture

By CHARLES M. MILLER

A Variety of Small Stools and Foot Rests

FOOTSTOOLS of reed are preferable, in the home, to those made of other materials, because of their light weight, rounded edges, and comfortable, yielding tops. Reed, rattan, and similar material, used in their construction, withstand hard wear, and will not easily mar floors or furniture, a feature not to be overlooked, especially since the footstool is a favorite seat or play table of children. Several types of stools and foot rests are shown in the illustration. A stool having a framework of dowels, covered with reed, and utilizing the frame to produce a paneled effect, is shown in Fig. 3. The upper dowel of the framework is covered and woven over with the top, in the somewhat lighter stool shown in Fig. 8; the legs are braced at the ends with reed, arched and covered with winding reed. The stool shown in Fig. 11 is designed with rounded lines, the bracing dowels being set low, and a panel of openwork woven into the sides. Figure 15 shows a foot rest, the framework of which is steamed and bent, and the top slanted to provide a more comfortable rest for the feet. It is strongly braced, paneled on the sides with winding reed, and ornamented with openwork scrolls. The details of the construction of the frames and the method of weaving the reed are shown in the other sketches.

Dowels, ¾ in. in diameter, are used for the main framework of all of the stools shown. The dimensions of the various stools may be made to suit individual taste, those suggested in each instance having been found satisfactory. A good size for the stool shown in Fig. 3 is: height, 9 in.; width, 11 in.; length, 15 in. The lower of the horizontal dowels should be set at least one-third the height of the leg from the top. The braces are notched at their ends to fit the curve of the legs, and finishing nails are driven into them through the legs. The corner joints are further reinforced by a binding of reed, placed over them. The holes for the spokes are bored through the braces before the construction is nailed together. They should be bored about 1¼ in. apart, spaced uniformly, according to the length and width of the stool. The tops of the legs should

project about 1/16 in. above the upper braces, so as to produce a level surface when the winding reed is applied.

The upper end of the legs must first be covered with winding reed, as shown in Fig. 2. Tack a strip of the reed on; then add successive pieces, as shown, until the end is covered. The joint of the leg and the lower brace must be reinforced, as shown in Fig. 2, by tacking winding reed over it horizontally. The braces must then be wound with winding reed, the spokes being inserted later. In winding the reed on the braces, tack one end of it to the brace at the left of a leg; then begin the winding on the brace to the right of the leg, and as each hole is encountered mark with pencil on the reed, so that if any of the holes are covered they may be found easily, when inserting the spokes. The marks should be made on the lower side.

The spokes extend from the lower edge of the bottom rail on one side to the lower edge of the corresponding rail or brace on the opposite side. Short spokes are fitted between the upper and lower rails at the ends of the stool. The top is woven complete before the sides are woven, the pairing weave being used. In this method two strands of reed are handled together, the first passing behind one spoke, and being below the second strand, and then passing in front of the next spoke, and being above the second strand, etc. This weave is shown in detail in Fig. 9, illustrating an article on "Taborets and Small Tables for the Summer Veranda," page 155, July, 1916. The weaving of the top includes the covering of the upper rails at the ends of the stool, which are wound in as spokes, the reed

FURS, to Keep Moths from.—Sprinkle them with spirits of turpentine. Or wash them with corrosive sublimate, 10 or 12 grains in a pint of warm water. Or use borax dissolved.

FURS, to Improve.—Warm bran in an oven. Rub it well into the fur several times. Shake and brush till free from dust. Rub light furs with magnesia.

HARNESS POLISH.—Take 2 ozs. of mutton suet, 6 ozs. of bees' wax, 6 ozs. of powdered sugar-candy, 2 ozs. of soft soap, and 1 oz. of indigo or lamp black. Dissolve the soap in a quarter of a pint of water; then add the other ingredients; melt and mix together; add a gill of turpentine. Lay it on the harness with a sponge, and polish off with a brush.

HORSES, to Water.—Water is as necessary to a horse as food, and horses are found to thrive better by having water *ad libitum* than by being stinted. The best way is to have the manger divided, so that corn may be in one half and the water in the other; by this plan the horse takes the water as he wants it, and not when it is offered to him. The plan of having clean water in the manger has been tried by a great number of the London merchants, and found to answer admirably.

USEFUL HORSE RECIPES.

Horse Ointment.—Resin 4 ozs.; bees' wax, 3 ozs.; hog's lard ½ lb.; turpentine, 6 ozs.; dissolve in a pipkin with a gentle heat; then add 2 ozs. of fine verdigris, stir well together, and strain the whole through a coarse cloth; cool for use. This is a good ointment for a wound, or bruise in flesh or hoof, broken knees, galled backs, bites, cracked heels, mallenders, or, when a horse is gelded to heal and keep off the flies.

Purge for a Horse.—Aloes 1 oz.; rhubarb, 2 drs.; oil of mint, 4 drops, made into a ball with honey.

Cordial for a Horse.—If the horse is weak through travel, give him a pint of warm ale, with 1 oz. of diapente in it. Diapente will comfort his bowels, drive out cold and wind, and may cause him to carry his food the longer.—Diapente is composed of gentian root, bay berries, bay leaves, birthwort, mint, and myrrh.

Sore Back.—If the saddle bruises his back and makes it swell, a greasy dishcloth laid on hot, and a cloth over it, bound on fifteen minutes, (with a surcingle), and repeated once or twice, will sink it flat. If it is slight, wash it with a little salt and water only. Alter the saddle, that it may not press upon the tender part, for a second bruise will

passing around them and being directed back in the opposite direction.

The weaving for the sides is carried around the stool continuously, passing around the legs. One of the strands in the pairing weave passes behind the leg, and the other must be wound around it an extra turn, to cover up the space otherwise exposed. The reed is wound around the legs to the lower end, the strand being tacked at the inner side of the leg.

The framework for the second type of stool is shown in Fig. 6. The two side rails are fixed into place by the same method used in making the first stool, and the frame is braced on the ends by sections of No. 12 or No. 14 reed. These are fitted into place and covered in the winding. The braces should be fitted to the curve of the leg, and nailed into place with small finishing nails. The ends where the braces join the legs and rails should be whittled down to a long, thin wedge, so that they may be bound in securely by the reed that is wound around the legs, as shown in Fig. 4.

The spokes in this model, as shown in Fig. 6, do not pass through the upper rails, but extend from one lower rail over the upper rails and to the lower rail on the opposite side. This makes it necessary that the upper rails be set slightly below and in from the top and outer edges of the legs. The lower rails should then be set in so as to be uniform with the upper ones.

The lower rails and the end braces are wound by the method used for the rails in the first stool. The tops of the legs are finished differently, however, as shown in Figs. 4 and 5. The weaving is begun at the lower rail, and proceeds until the side panel is filled to the under edge of the upper rail.

be worse than the first.

Splint.—The splint is a fixed, callous, bony excrescence, growing upon the flat of the inside or outside, of the shank bone; a little under, and not far from the knee, and may be seen and felt.—*Cure.* To take it off, first cut the hair close, then gently beat it with a round rule until it appears hot to the touch, then rub hard soap all around the edge of the splint, to prevent the blister affecting any other part, and apply on the splint the following blister ointment: mercurial ointment, 1 oz.; Spanish flies, 2 drs.; mixed well together; a little of this may be applied once a week until the splint is removed.

Spavin.—The spavin is of the same nature, and appears in like manner, on the instep bone behind, not far below the hough.—*Cure.* The same blister as recommended for splints; if it fails, firing and turning the horse to grass for 3 months, is the best method.

ICE CREAM.—Put into a bucket 1 lb. of ice broken very small; throw two handfuls of salt, among it, and have it in the coolest place you can find. Put the cream into an ice-pot, and cover it; immerse it in the ice, and draw the ice round the pot, so as to touch every part. In a few minutes put a spatula or spoon in, and stir the parts that ice round the edges to the centre. Stirring quickly increases the cold. There should be holes in the bucket to let out the ice as it thaws.

The cream for icing is thus made:—New milk, 1 quart; yolks of 6 eggs; fine sugar, 4 ozs. Mix. Strain. Heat gently, and then cool.

INDELIBLE INK.—*German Receipt*—Dissolve 20 grains of sugar in 30 grains of water, and the addition to the solution of a few drops of concentrated sulphuric acid; the mixture is then heated, when the sugar is carbonized by the action of the acid. It is said that the writing is not only of a solid black colour, but that the acid resists the action of chemical agents.

INK, Invisible or Sympathetic.—Dissolve bismuth in nitrous acid. When the writing is exposed to the vapour of sulphur, it will become quite black.—Make a weak solution of galls; write with it. To make it visible, moisten with a weak solution of copperas; moisten the paper with a solution of prussiate of potass, and it will appear blue.——Sulphate of copper (blue vitriol) and sal ammoniac, equal parts, dissolved in water, write colourless, turn yellow when heated.——Onion juice, like the last.——Solution of salt or saltpetre, shows when heated.——Write with starch water—a weak solution of iodine will make it visible.

The weavers cannot then be returned at the corner, and are cut off to extend 2 in. beyond the leg. Their ends are thinned out, and then brought around the corner against the upper rail on the end, as shown in Fig. 5. Alternately they are turned down on the leg and against the end rail, producing a covering for the corner. The strands of the top are woven over the thinned-out ends, and bound over the joint of the braces with the upper rail. The corners may be beaten gently with a block of wood to smooth them, and to bring the weavers firmly together. The weavers pass twice around the legs, as each strand is brought to the leg, as shown in Figs. 5 and 7. It will be found convenient to place the spokes in only one lower rail, as in Fig. 6, while weaving the first side panel, and the top. As the work proceeds the spokes are bound down to the upper end rails, and when the middle of the second side panel is reached, they are trimmed off and fitted into their holes, on that side.

The third stool differs fundamentally from the preceding ones in that the framework is curved at the upper ends, and the weaving of the top is carried down over the ends. The framework is shown in detail, in Fig. 9. Ash dowels, ¾ in. in diameter, are used for the framework, and the rails are notched into the main sections, and nailed, as were those in the preceding stools. The length of the curved dowels must be determined carefully, and it is desirable to have the stock longer than is necessary for the finished pieces, so that inaccuracies in bending may be allowed for properly. The distance between the legs should be such that a space of ½ in. is provided between the legs and the first hole for the side spokes, and the intervening spokes should be placed 1 in. apart. A satisfactory size is to make the stool 8 in. high, the end rails 8 in., and the side rails 13 inches.

The method of bending the dowels is shown in Figs. 12 and 13. They must be soaked in hot water or steamed, and clamped around the form as indicated, being left to dry. A pipe fitted over the ends of the dowels, to give leverage, will aid in bending them. The form is made by fitting pegs, suitably spaced, into a board, ⅞ in. or more in thickness. The curved pieces may be braced temporarily, as shown, and removed from the form when partly dried, so that it can be used quickly for the second piece. The pegs must be set close enough together so that the curve at the upper ends of the legs will not be too large, making the legs appear short. Care must be taken in bending this short curve, as the dowels are likely to break if the curve is quite abrupt. By setting the pegs solidly and making them long enough, two pieces of dowel rod may be curved in the form at the same time, and permitted to dry. A convenient tray of galvanized iron, for use in heating water for the moistening of the dowels, is shown in Fig. 10. It is 28 in. long, but may be made shorter if the points at which curves are to be made are moistened separately. A wash boiler, or any other suitable vessel, may be used for heating the water and dipping the dowels into it. After being shaped, the pieces are trimmed off to the proper height on the leg portions. Holes for the spokes are then bored through the lower and side rails, and they are notched and nailed to the legs.

The cross rails of the framework, shown in Fig. 9, are fixed into place by the method used in the previous models. The lower rails should be set about 2 in. from the floor, and are bored for double spokes. The rails are set with their outer edges ⅛ in. in from the edges of the legs, so that the weaving will be flush with the surface of the legs, rather than project slightly beyond it. The spokes for the ends and seat, or top, pass from one lower rail on one end to the corresponding rail on the other end, and are supported on the upper end rails. There are no corners to be fitted with the winding reed in this model, as the windings continue over the curves at the ends and down over the latter, by the same method of weaving as used in the top. The weaving is begun at the lower rails, and passes completely around the sides and ends of the stool, until about 1½ in. has been covered, up from the lower rails. The ends only are then covered, the strands of reed passing around the curved portion of the upper rails, and around the dowels forming the support for the top, in weaving back and forth.

The ornamental weaving at the sides of the stool is produced by spreading out the double spokes and conducting them to the proper holes in the upper rails. Several types of design may be made by crossing the spokes in various ways before setting them into the holes in the rails. The short spokes in the sides are permitted to remain with their upper ends free and longer than necessary while the 1½-in. lower section is woven. They must be cut carefully to the size necessary to form the desired design, and the ends glued into the holes.

The stool shown in Fig. 15 is designed as a foot rest, with a slanting top. It is similar in general construc-

INSECTS on Plants to Destroy.—Tie up sulphur in a muslin bag, and dust the leaves of young shoots and plants. A dredging box may be used. Sulphur increases verdure. A weak solution of alum sprinkled upon plants is not relished by insects.—Or, a thin mixture of soap and oil of turpentine painted on the stems of trees.—Or, use a solution of borax.
Painting the walls behind rose trees, fruit trees, &c., prevents the visits of spiders, earwigs, caterpillars, &c. The best paint for this purpose is gas tar.

ITCH.—It is a skin desease, infectious. Sometimes it is caused by poor living, unwholesome food, bad air, unventilated and dirty houses, dirty beds and clothes. The itch begins with small eruptions, on the joints of the fingers, on the wrists, thighs, &c. They cause a most intolerable itching, the scratching of which only spreads the disease.

Remedies:— Sweet oil, 1 pound; suet, 1 lb. Melt and macerate; then add powdered nitre, 3 ozs.; powdered alum, 3 ozs.; powdered sulphate of zinc, 3 ozs.; oil of aniseed, oil of spike, and oil of origanum, to perfume.—Or, mix 2 ozs. of lard with 1 oz. of sulphur-vivum, and a few drops of essence of lemons. Before going to bed rub this well into the affected parts. In the morning wash with soap and warm water; change the linen and clothes. Repeat the application, if necessary. Take at the same time flour of sulphur and cream of tartar, in milk, beer, or treacle.

Frequently take a Warm Bath. The greatest cures have been effected by it.

Wash the parts affected with strong rum.—Tried.—Or, anoint them with black soap, but wash it off soon.—Or, steep a shirt half an hour in a quart of water mixed with half an ounce of powdered brimstone. Dry it slowly, and wear it five or six days. Sometimes it needs repeating.—Tried.—Or, mix powder of white hellebore with cream for three days. Anoint the joints for three mornings and evenings. It seldom fails. —Or, beat together the juice of two or three lemons, with the same quantity of oil of roses.—Anoint the parts affected. It cures in two or three times using.

The following is said soon to effect a cure:—Sulphur-vivum, Venice turpentine, 1 oz. each; lard, ½ oz. Melt the lard and turpentine; add the sulphur. Apply several times a day.

Or, wash the body well in warm water, and rub it with the following preparation:—Lime, 2 ozs.; sulphur-vivum, 2 ozs. Mix in 1 quart of water. Pour off, and use it when clear.

A decoction of white hellebore, with a little lavender water, has been recommended.

IVORY and BONE, to Stain.

tion to that shown in Figs. 8 and 11, the framework being made of dowels, bent to the shape indicated by means of a form. The top and ends are woven in the manner described for the previous model. A point of difference to be noted is the bracing by means of a woven panel below the side rails, as shown in Fig. 15. This feature may be carried around the ends also, or the ends may be braced to the lower side panel by the method of bracing shown in Fig. 4. The rails around the stool are all on the same level. The double spokes for the top are fixed into the end rails, the spokes for the side panels into the side rails, and the smaller dowel placed at the lower edge of the side panels, as a support for the twisted weaving shown. The weaving of the top and the panels is by the method used in the previous model. The scrolls fitted into the open portions of the sides are tacked into place, and the strands of weaving reed carried over them, where the curves touch the upper and lower rails. A variety of designs may be worked out for the openwork. The scrolls are made of No. 6 or No. 8 reed, and should be formed on a base, as in Fig. 12, brads being used to hold them in shape until dry.

Another type of foot rest with a slanting top is shown in Fig. 14. The framework is built up of dowels, straight sections only being used. The joints are fastened by the method used in the first and second models described. The method of covering the frame is essentially the same as for the stool shown in Fig. 15, or an adaptation of that used in Fig. 11 may also be applied. Where facilities for steaming or moistening the dowels are not to be had conveniently, this type of construction will be found satisfactory, the designs being limited to straight lines, however. The method of covering the framework used in Fig. 3 is also available for the framework shown in Fig. 14, and the corners may be finished as shown in Fig. 2. Numerous variations and combinations of the types shown may be worked out readily after one has become reasonably familiar with the possibilities of woven-reed construction.

A Woven-Reed Footstool

By CHARLES M. MILLER

The various materials referred to in this article by number or size were described in detail in an article on "A Reed Basket" in Volume I of The Survivor.

REED furniture has become very popular within the last few years, and the newer designs and methods have been so attractive as to place this constructive effort among the handicraft series of modern art. It is possible so to analyze, simplify, and illustrate this work as to make it feasible for amateurs, and at the same time there are possibilities which involve problems that may try the ability of the skilled workman. In other words, there are possibilities of progress in this kind of furniture making. There are places where careful weaving is the principal aim; again particular attention will be given to corners, or, perhaps, a nicety of modeling will be found necessary to bring out the proper curves involved.

Each piece of reed furniture has a framework, usually of dowels, but it may also be made of boards in such models as small tables, dressers, bedsteads, chests, etc. The board construction is more often covered with flat reed. In footstools there are both kinds of framework. The illustrations show the same parts marked with the same letters throughout the series of sketches.

The framework of the stool is shown in Fig. 1, in which the rails and posts are made of dowels, ¾ in. in diameter, and the braces of dowels, ⅝ in. in diameter. It will be noticed that the posts extend to the top of the frame for strength in this manner of construction. If the rails rested on top of the post S, the nails would have to be driven into the end grain of the wood,

The Framework of the Stool is Made of Large Dowels, Then Covered with Windings of Reed and a Woven Reed Top and Apron

—*Black*;—Rub over with diluted oil of vitriol; wash, and then steep in nitrate of silver and good ink.—*Blue*; steep in a strong solution of extract of indigo and a little potash.—*Green*; dissolve copper in nitric acid, and steep the ivory in it.—Steep in oxalic tin, and then in a strong decoction of Brazil wood, or lac dye, and alum.—*Purple*; nitric acid, 2 parts; sal ammoniac, 1 part; mix, and steep the ivory in it.

KERNELS, to Blanch.—Simply put them into boiling water a minute or two; rub them between a clean cloth, and the brown skins will soon peel off. *Almonds* and other kernels may be blanched.

KETTLES, Incrustation, or Furring, to Prevent.—Keep in the vessel a clean marble, a cockle, or oyster shell; these will attract the particles of sand.

LAXATIVE POWDER for Horses.—Crocus of antimony, finely levigated, nitre, cream of tartar, and flour of sulphur of each 4 ozs. Powder and mix well together. A table-spoonful of this mixture may be given every night and morning a few times, in a mash of scalded bran, or a feed of corn moistened with water. This powder is good for horses kept on dry meat; and for stallions in the spring, as they keep the body cool and open, and cause them to cast their coat, and make their skin as bright as silk.

LOBELIA.—An American plant, containing most valuable medical properties. It was first used with great advantage, as an emetic, by the American Indians, and was brought into notoriety by Dr. Samuel Thompson. It is emetic and stimulating, and Dr. Beach says, "from its action on the great sympathetic nerve, its effect is felt throughout the whole system. It exerts a peculiar action upon the trachea and bronchial vessels, expelling all collected mucus." It must therefore be very valuable in asthma, croup, hooping cough, and consumption. The greatest benefit from it has been found in dyspepsia, coughs, asthma, liver complaints, &c. It has relieved asthmatic subjects when on the point of suffocation by accumulated phlegm, cough, &c. Also in pneumonia of infants.

It is also a valuable sudorific; it relaxes the constricted pores of the skin, and promotes free perspiration. The leaves, seeds, and seed-vessels may be given in powder, and tincture. Dose of the powder, from a drachm, or a small teaspoonful; of the tincture, a teaspoonful.

LOBELIA, Acid Tincture of.—Lobelia herb, 1 oz.; cayenne, 2 drs.; vinegar, half a pint. Boil the vinegar, and put all into a bottle, cork well for 7

which makes the strength depend entirely on the holding power of the nail in this position, as there is no binding of the upper part to the posts in the weaving. With the post extending to the top, the nail passes through the upper part of the post and into the end grain of the rails, and the rails are bound together horizontally by the weaving.

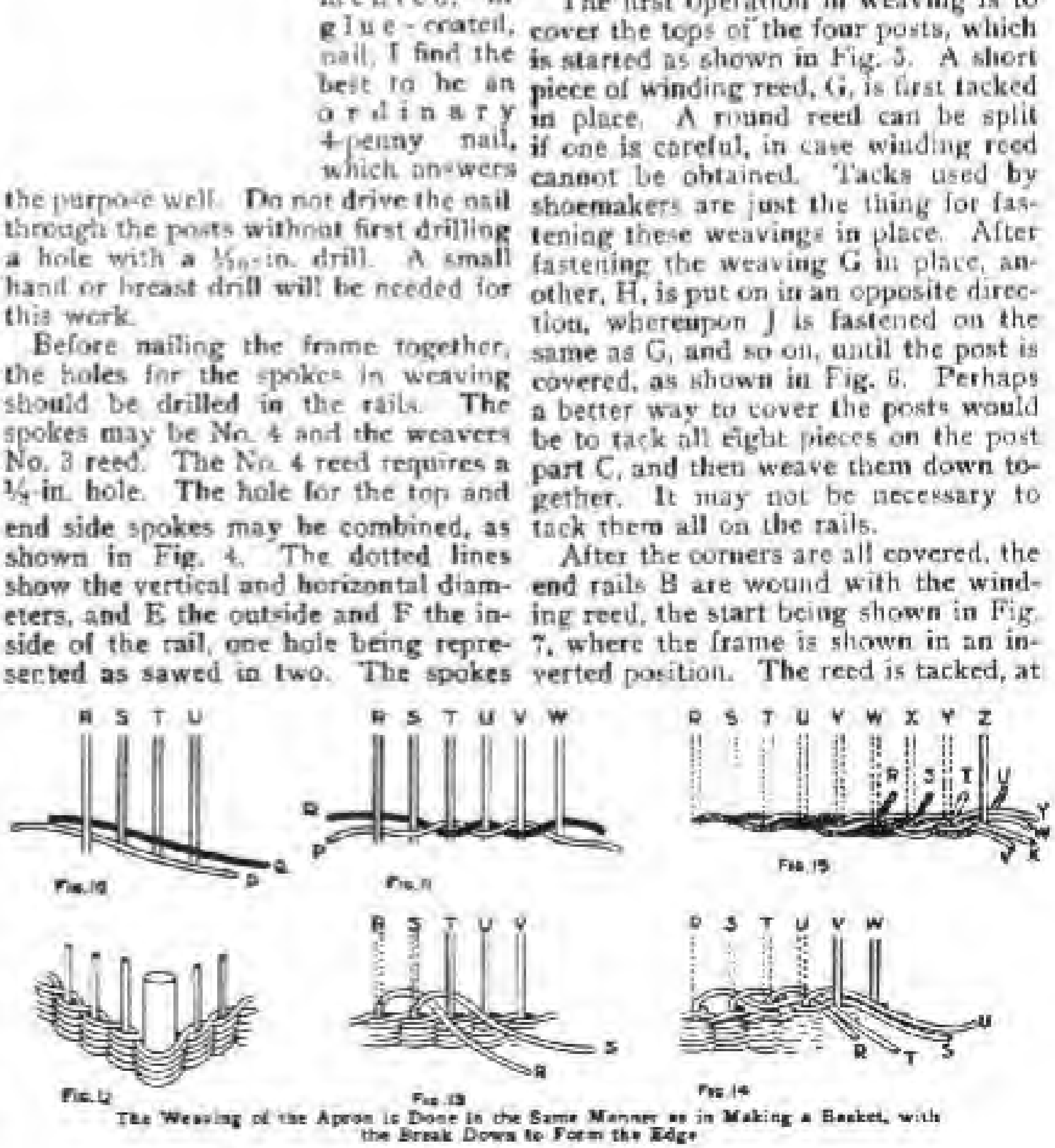
The material for the frame consists of the following dowel stock: two pieces for rails, ¾ in. by 14 in. long; two pieces for rails, ¾ in. by 9 in. long; four posts, ⅝ in. by 7 in. long, and two braces, ⅝ in. by 17 in. long. These pieces are shown in Fig. 2. If notches are cut with a small saw, a coping saw preferred, in the ends of each rail and in the braces, as shown in Fig. 3, they will fit to the posts better and make a stronger joint. While different makers use a finishing nail; a barbed or corrugated, nail; or a cemented, or glue-coated, nail, I find the best to be an ordinary 4-penny nail, which answers the purpose well. Do not drive the nail through the posts without first drilling a hole with a 1/16-in. drill. A small hand or breast drill will be needed for this work.

Before nailing the frame together, the holes for the spokes in weaving should be drilled in the rails. The spokes may be No. 4 and the weavers No. 3 reed. The No. 4 reed requires a ⅛-in. hole. The hole for the top and end side spokes may be combined, as shown in Fig. 4. The dotted lines show the vertical and horizontal diameters, and E the outside and F the inside of the rail, one hole being represented as sawed in two. The spokes for the top extend down and out at the ends, and each may be of one piece, 32 in. long. As there are no spokes at the top extending to the side pieces, short spokes must be inserted at the right time for the side weaving. The location of the holes in the side rails is shown in Fig. 2. The holes in the side rails may be drilled straight in the wood.

The pieces may now be nailed together to form the frame, as shown in Fig. 1. If the top of the side rails A are set about 1/16 in. below the tops of the posts, the weaving will be almost level, as the winding reed is thinner than the round reed. The braces D are halved at the center, on a slant, to bring their upper surfaces on a level when they are in place. The length of 17 in., as given in the material list, is not accurate, as sufficient length is given to allow the ends to be cut, in fitting them in place after the frame is assembled. The posts should stand vertical and square. Try the braces before nailing them in place, to see that they do not draw the frame out of shape.

The first operation in weaving is to cover the tops of the four posts, which is started as shown in Fig. 5. A short piece of winding reed, G, is first tacked in place. A round reed can be split if one is careful, in case winding reed cannot be obtained. Tacks used by shoemakers are just the thing for fastening these weavings in place. After fastening the weaving G in place, another, H, is put on in an opposite direction, whereupon J is fastened on the same as G, and so on, until the post is covered, as shown in Fig. 6. Perhaps a better way to cover the posts would be to tack all eight pieces on the post part C, and then weave them down together. It may not be necessary to tack them all on the rails.

After the corners are all covered, the end rails B are wound with the winding reed, the start being shown in Fig. 7, where the frame is shown in an inverted position. The reed is tacked, at



The Weaving of the Apron is Done in the Same Manner as in Making a Basket, with the Break Down to Form the Edge or 8 days. Dose for a cough, half a teaspoonful in any pleasant vehicle. Repeat when the cough is troublesome. It will require a larger dose for asthma or croup.

LOBELIA, Emetic.—Take lobelia powder, 1 ounce; boiling water, 1 pint; mix, and make an infusion. Dose: A fluid ounce to be taken every half hour, until vomiting ensues.

LOBELIA POULTICE.—Linseed meal, ½ oz.; slippery elm, 1 oz.; powdered lobelia, 1½ oz.; ginger, 1 oz.; whiskey sufficient to make it. Good for all inflamed parts, as the side in pleurisy, liver complaint, rheumatism, lumbago.

LOBELIA TINCTURE.—Put 1 oz. of the powdered plant to 1 quart of whiskey. Infuse 7 days. Dose, a teaspoonful when the cough is troublesome. The tincture can now be bought at most Herbal Stores.

LOOKING-GLASSES, to Silver.—Take a sheet of tinfoil, and spread it upon a table, then rub mercury upon it with a hare's foot till the 2 metals incorporate. Lay the plate of glass upon it, and load it with weights, which will have the effect of pressing out the excess of mercury that was applied to the tin-foil. In a few hours the tin-foil will adhere to the glass and convert it into a mirror. About 2 ozs. of mercury are sufficient for covering 3 square feet of glass.

MAGGOTS IN SHEEP, to Destroy.—Water, 1 quart; spirit of turpentine, a table-spoonful; sublimate of mercury, as much as will lie upon a shilling; cork in a bottle, with a quill through the cork, so that the mixture may come a little at a time. Shake before using. Pour a little of the mixture upon the spot where the maggots are, and they will creep upon the top of the wool, and fall off dead. Apply afterwards a little train oil to the place.

MARIGOLDS, to Cultivate.—Pull up all those plants, whose flowers are less double, as soon as they appear, that they may not impregnate the others with their farina. Save the seeds from the largest and most double flowers. Sow the seeds in April in places where the plants are to remain.

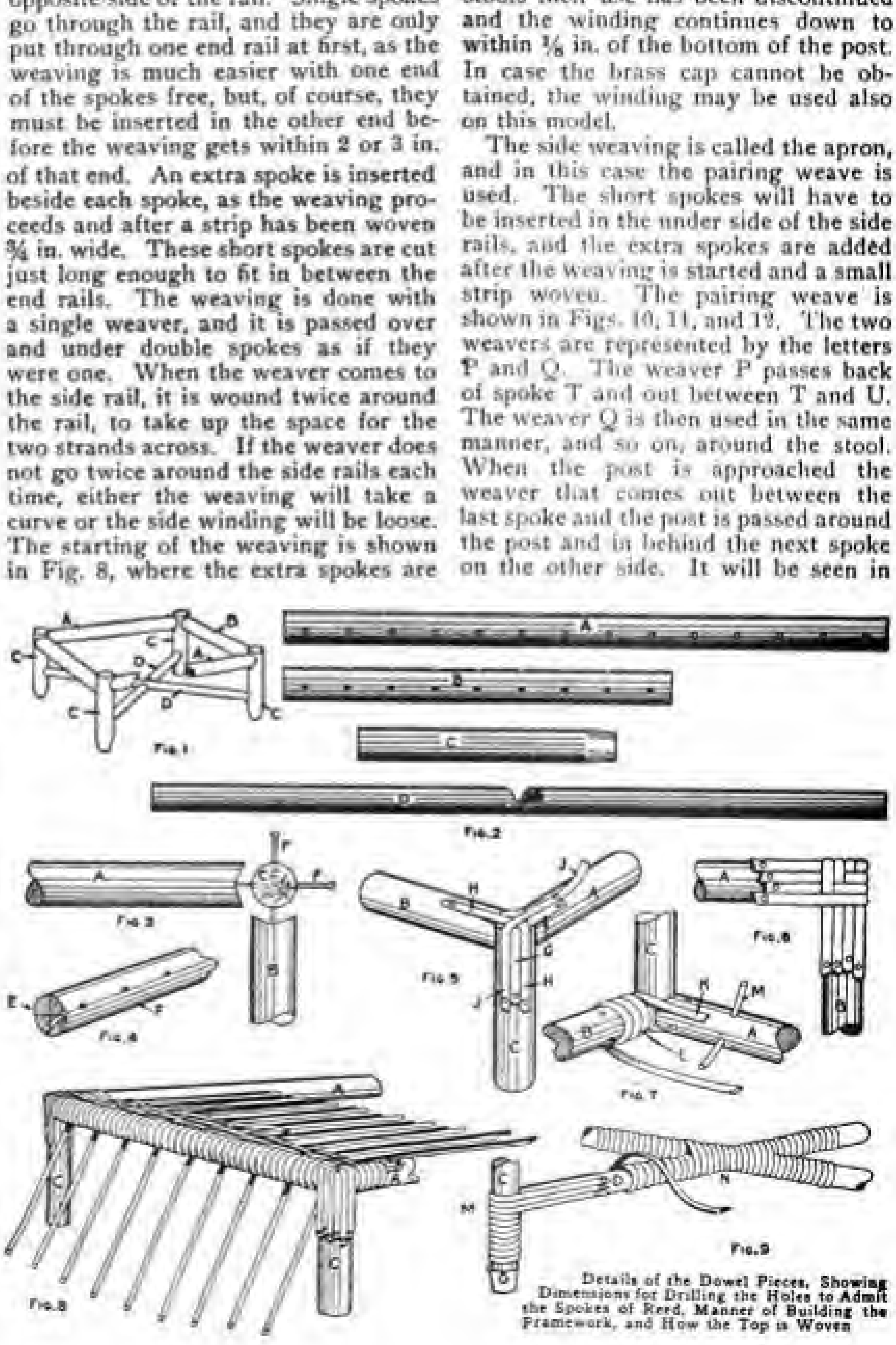
MARIGOLD CHEESE.—Pound marigold petals in a mortar, and strain out the juice; put it into the milk when you put in the rennet, and stir them together; the milk being set, and the curd come, break it as gently and as equally as possible; put it into the cheese vat, and press it with a gentle weight. Manage the same as other cheeses.

MILDEW, to Remove.—Mix

K, to the side rail, and whenever the winding comes to a hole, a pencil mark is made to locate the hole later. This mark is shown at L. When the two end rails are wound, push a bodkin, or other steel point, in between the windings where the marks are located, to make way for the insertion of the spokes. It may appear to an observer that the spokes could be put in before the winding, but the winding cannot be properly done after the spokes have been inserted, as the windings would separate too much around them. The hole must be opened up through to the opposite side of the rail. Single spokes go through the rail, and they are only put through one end rail at first, as the weaving is much easier with one end of the spokes free, but, of course, they must be inserted in the other end before the weaving gets within 2 or 3 in. of that end. An extra spoke is inserted beside each spoke, as the weaving proceeds and after a strip has been woven ¾ in. wide. These short spokes are cut just long enough to fit in between the end rails. The weaving is done with a single weaver, and it is passed over and under double spokes as if they were one. When the weaver comes to the side rail, it is wound twice around the rail, to take up the space for the two strands across. If the weaver does not go twice around the side rails each time, either the weaving will take a curve or the side winding will be loose. The starting of the weaving is shown in Fig. 8, where the extra spokes are inserted along the side of each spoke that runs through the end rails.

After the spokes have been inserted in the opposite end rail and the weaving in the top completed, the braces and posts should be wound. Where the braces D connect to the posts C, three strips of the winding reed are passed around the post and tacked on both sides of the braces, as shown at M, Fig. 9. Where the braces cross, the winding passes around both pieces for a short distance, as shown at N. It is quite appropriate to use the brass caps O on this model, but on many stools their use has been discontinued and the winding continues down to within ⅛ in. of the bottom of the post. In case the brass cap cannot be obtained, the winding may be used also on this model.

The side weaving is called the apron, and in this case the pairing weave is used. The short spokes will have to be inserted in the under side of the side rails, and the extra spokes are added after the weaving is started and a small strip woven. The pairing weave is shown in Figs. 10, 11, and 12. The two weavers are represented by the letters P and Q. The weaver P passes back of spoke T and out between T and U. The weaver Q is then used in the same manner, and so on, around the stool. When the post is approached the weaver that comes out between the last spoke and the post is passed around the post and in behind the next spoke on the other side. It will be seen in



Details of the Dowel Pieces, Showing Dimensions for Drilling the Holes to Admit the Spokes of Reed, Manner of Building the Framework, and How the Top is Woven soft soap with powdered starch, half as much salt, and the juice of a lemon, and lay on with a brush. Let it lay on the grass day and night till the stain is gone. Or, take 2 ozs. of chloride of lime, pour on it a quart of boiling water, then add 3 quarts of cold water; steep the linen 10 or 12 hours, when every spot will be extracted.

Mix oxalic acid, citric acid, and milk together; rub into the linen; repeat as it dries; wash, and bleach on the grass.

MUSTARD.—This plant is both culinary and medicinal. As a condiment it is generally used and esteemed. As a cataplasm or poultice, it is made thus;—powdered mustard seed, 4 ozs.; vinegar, as much as is sufficient to mix it for a plaster; it is stronger by adding horse radish, scraped, 2 ozs. It is employed as a stimulant; it often inflames the part, and raises blisters, but not so perfectly as cantharides. Sometimes they are applied to the soles of the feet, in the low state of acute diseases, for raising the pulse, and relieving the head.

The white mustard acts not only on the bowels, but also on the skin. It wonderfully strengthens the whole line of the alimentary canal, improves the appetite, the digestion, and promotes sleep, and the health generally.

When the seed is used to remove constipation, take it an hour before breakfast fasting. A small table-spoonful is sufficient.

MUSTARD, to Make.—Mix the best Durham flour of mustard by degrees with boiling water to a proper thickness, rubbing it perfectly smooth; add a little salt, and a little tincture of cayenne, and keep it in a small jar close covered, and put only as much into the glass as will be used soon, which should be wiped daily round the edges.

OPODELDOC.—Dissolve 1 oz. of camphor in a pint of spirit of wine; then dissolve 4 ozs. of hard white Spanish soap, scraped thin in 4 ozs. of oil of rosemary. It may be improved by adding 2 ozs. of ammonia, tincture of aconite, or opium 1 oz., and a little oil. It is a good application for sprains, lumbago, pained limbs, weakness of joints, &c. Mixed with tincture of cantharides, or tincture of cayenne, it becomes more effectively stimulant.

PARSLEY, and other Herbs to Dry—Pick them clean from all decayed leaves. Put in a sieve; cover with blotting paper, and expose to the sun; or in a very slow oven, and turn them often; the quicker they are dried the better. Aromatic herbs, if not dried quickly, will lose much of their flavour. They may be dried also in a Dutch oven. Rub them, and pass through a

the pairing weave that the weaver behind is always thrown over the other weaver. This gives the appearance of a rope twist to the weaving, and also cinches it to the spokes and prevents slipping. Always pass the one weaver around the post twice to take up the space for the one that cuts across the corner. The weaving of the sides or apron is done with the object turned upside down, where it is in a good position for finishing off, which is sometimes called breaking down.

If the weaving has been carried far enough, the extra spokes are cut off even with the weaving, and the breaking down may be done as follows: The spoke R, Fig. 13, is shown turned down back of the spoke S, and S back of T and out. The spoke R, as shown in Fig. 14, is back of S, in front of T, back of U, and out between U and V, but as R is brought out, the spoke T is brought down back and parallel with R. Likewise the spoke S passes back of V, and U is brought down with it. The spoke T is brought back of W and V is brought down back of it. The short end of R is inserted under the roll, between the roll and the weaving, and is left extending on the inside. If it is too long, it can be cut off close to the inside of the weaving. In Fig. 15, all the short ends are shown brought through to the back as far as the weaving is illustrated. At the corners, the posts are used as spokes. To finish the

roll, the spokes will have to be inserted through the roll, to correspond with the rest of it; hence, the beginning of the roll should be left loose, as in Fig. 13.

In weaving, the weavers should be kept wet, but not the spokes. Do not put the reed in water and leave it for any length of time, as it will become discolored. About 15 minutes will be sufficient to make the reed pliable, then it is best to have a sponge and bucket of water at hand, to dampen long weavers frequently by drawing the reed across the wet sponge. Besides being more workable, the wet reed, held in place until dry, stays curved in the form woven much better. Some workmen leave the reed in water for a long time and depend on bleaching to whiten it, but so much of the bleached work looks like a poor job of painting that it is much better to keep it white from the start. In case bleaching is found necessary, a little chloride of lime in water makes a good bleacher. Avoid making the solution too strong. It should be put on with a brush, so as to get it into the interstices of the weaving, whereupon the work is placed in the sunshine to dry.

Any kind of reed used will have some of the small hairlike fibers sticking out after the weaving is complete, and this should be singed off with a gas flame. A blowtorch is good for this purpose. Be careful not to scorch the weaving.

Woven Reed Furniture

Taborets and Small Tables for the Summer Veranda

By CHARLES M. MILLER

UTILITY and ready portability are well recognized features of woven-reed furniture, but the qualities which make it especially attractive for summer use in the open air, or on the veranda, are its inviting comfort and graceful lines. While furniture of this type arranged in suites makes a particularly harmonious showing, individual pieces may be used in combination with other furniture, lending a touch of variety. Small tables or taborets, of light weight and simple design, may be made by the novice, and may be adapted to a variety of uses. Footstools, jardinière stands, sewing tables, card tables, and smoking stands are some of the possibilities. Three representative types are shown in Figs. 1 to 3, and the general method of construction as well as the details of the weaving are also illustrated.

A serviceable taboret or stand is illustrated in Fig. 1. It is 18 in. high, and 17 in. in diameter on the top. The sides are 9 in. wide at the top and 14 in. at the bottom.

The framework for the top of the stand consists of a disk of wood, 16 in. in diameter, with a similar one, 14 in. in diameter, directly underneath, the edge being set under 1 in. all around. Four legs of 1-in. doweling support it, and two cross braces of doweling are placed between diagonally opposite corner posts, behind the woven portions of the side. The grain of the wood in the upper disk should run at right angles to that of the lower, to prevent warping, and the disks should be fastened together with nails or screws. Avoid putting them into the lower disk, where the legs are to be fixed.

sieve. Parsley thus prepared is very pleasant and useful ; it breaks into parts as small as are obtained by chopping. When parsley and butter are wanted, it is only required to put a small quantity into the saucepan with the butter.

All dried herbs should be kept from the air in paper bags.

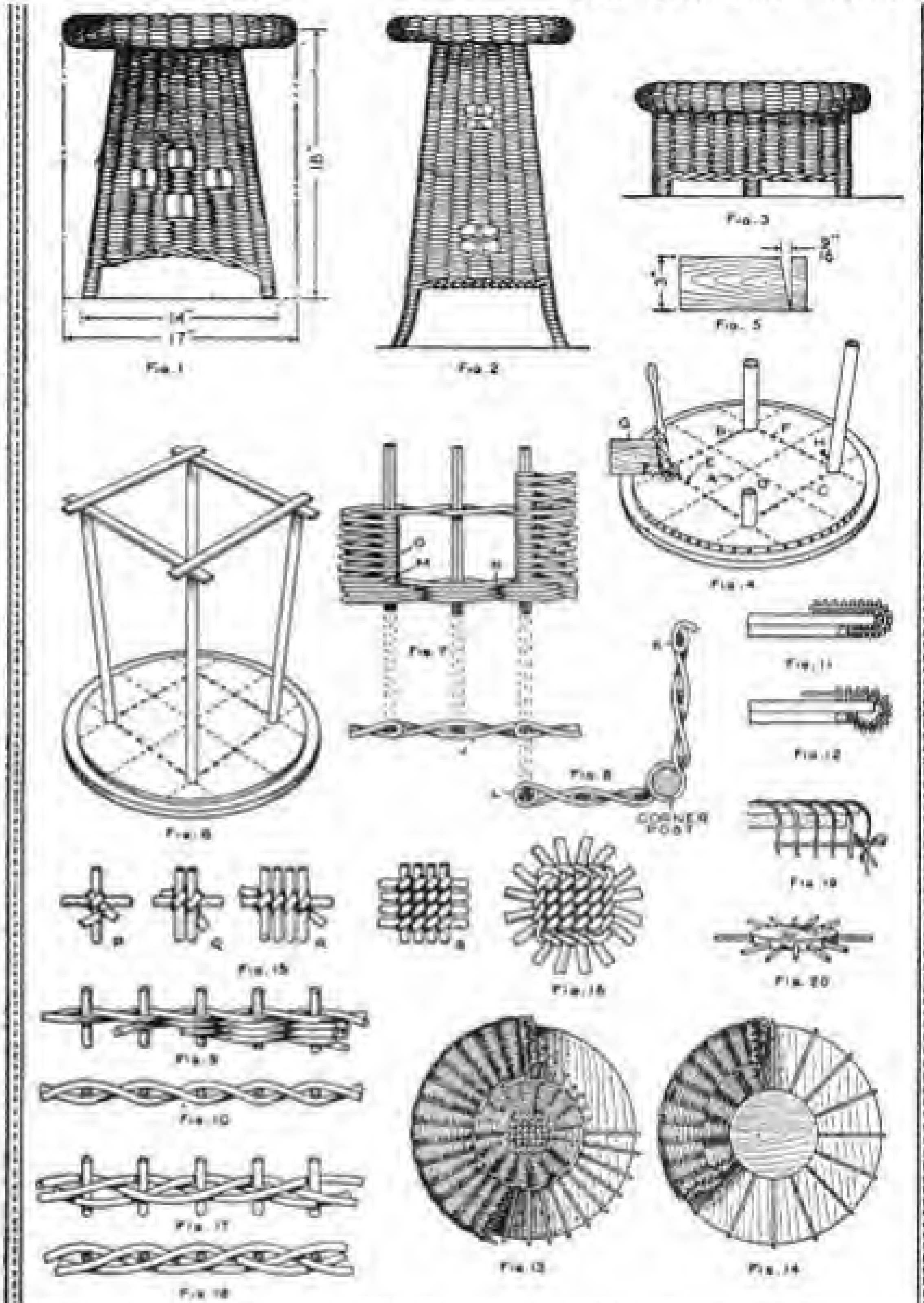
PENNYROYAL.—This plant is perennial. It flowers in August and September. It is warm, pungent, aromatic, stimulating, and diaphoretic ; like spearmint, but not so agreeable. It contains a volatile oil which is obtained by distillation. The infusion is warming to the stomach, and allays sickness. It relieves spasms, hysterics, flatulency, and colic, and promotes expectoration in dry consumptive coughs. It promotes perspiration, and is most valuable in obstruction of the menses.

PENNYROYAL WATER.—Pennyroyal leaves, dry, $1\frac{1}{2}$ lb. ; water, from $1\frac{1}{2}$ to 2 gallons. Draw off by distillation, one gallon. It is a specific remedy for female obstructions. It is good for gout, rubbing the parts with it till they are red ; and if salt be added, it is good for the side in liver complaints. It is very warming to the stomach, produces perspiration, and therefore is good for coughs, asthma, &c. An infusion of the herb in hot water is nearly as good.

PENCIL DRAWINGS, to Fix.—Dissolve white resin in spirits of wine ; lay the pencil drawing on its face upon a sheet of clean paper, and brush the back of the drawing with the solution. This penetrates through the paper, and as the spirit evaporates, the resin is deposited as a varnish on the drawing. It does not cockle the paper, which watery solutions will do ; and as the brush only passes over the back of the drawing, none of the pencil marks are in any degree removed.

Pencil, or Chalk Drawings, to Fix.—Immerse the drawing in a weak solution of isinglass ; allowing no part of the drawing to remain without the isinglass passing over it, or it will look spotty. Drain it, by holding the drawing up by one end over a plate.

PLASTIC MATERIAL for forming various objects new.—By Professor Purkins. Five parts of whiting are mixed with a solution of one part of glue. When the whiting is well worked up into a paste with the glue, a proportionate quantity of Venetian turpentine is added to it, by which the brittleness of the paste is destroyed. In order to prevent its clinging to the hands whilst the Venetian turpentine is being worked into the paste, a small quantity of linseed oil is added from time to time. The mass may also be coloured



Taborets, of Light Weight and Simple Design, may be Made by the Novice and Adapted to a Variety of Uses in the Home. They Are Particularly Attractive for the Summer Veranda. Sewing Tables, Jardiniere Stands, Taborets, Footstools, Card Tables, and Smoking Stands Are Some of the Possibilities. A Taboret, or Small Stand, is Illustrated in Fig. 1, and the Details of Its Construction are Also Shown. The Tall Stand Illustrated in Fig. 2 Involves the Same General Principles of Construction, Modified to Suit the Framework. The Footstool Shown in Fig. 3 Is Typical of Stands Having Vertical Sides

To locate the position for the legs, draw a diameter on the under side of the top, as at A, Fig. 4, and 4 in. on either side of it draw parallel lines B and C. Draw another diameter, D, at right angles to A, and draw the parallel lines E and F 4 in. from the diameter D. Where the four outside lines intersect will be the centers of the holes for the legs. These holes are not bored perpendicularly, but are slanted to conform to the slant of the leg. A template should be used in guiding the bit, as shown at G, Fig. 4. It may be constructed of wood, 3 in. wide and 5 in. long, Fig. 5. Place the gauge just outside the edge of the hole to be bored. Nail it to the board lightly on the diagonal, as shown, and guide the bit against it.

Before the legs are fixed into place finally, the holes for the spokes of the side should be bored. The parallel lines of Fig. 4 now serve another purpose, that of giving the location of the spokes. Place one spoke ½ in. from each leg, and the others 1 in. apart. The legs are utilized as spokes in the by kneading in any colour that may be desired. It may be pressed into shapes, and used for the production of *bas reliefs* and other figures, such as animals &c. It may also be worked by hand into models, during which operation the hands must be rubbed with linseed oil; the mass must also be kept warm during the process. When it cools and dries, which takes place in a few hours, it becomes as hard as stone, and may then be employed for the multiplication of these forms.

SMOKY CHIMNEYS.—Certain chimneys draw well ordinarly, but are subject to violent fits of smoking in certain winds, and generally in boisterous weather, blowing both flame and smoke into the room to an intolerable extent. For this particular class of nuisance I have for many years past adopted a very cheap and permanent remedy, which has never failed. Instead of a common chimney-pot, I fix, in the like manner, a 9-inch drain-pipe, 2 feet long, socket downwards, which gives it a firm seat; and on this I fix another like drain-pipe, having a 4-inch double junctions, inserted obliquely into the 9-inch pipe. When the wind blows, it rushes into these lateral openings, which, having a turn upwards, direct its blast against the downward current from the top of the pot. The fixing should be in cement, and you have a cheap chimney-top, which will neither perish nor blow off. I use nothing but drain-pipes for chimney-pots, which, as well as being cheaper and stronger than any thing else, admit of a second and third story being added to them if the draught be dull, or the branch pipe top as I have described, if subject to downward gusts. For kitchen flues, 12-inch pipes are safer.—T. E. in the *Builder*.

To increase the draught in the chimney, some persons make a hole in the hearthstone, providing there is a room below, and cover it with a ventilator to protect it from cinders and ashes.

Or, inflate a large ox's bladder, and tie it by the neck to the middle of a stick, and place it across a chimney, 2 feet from the top, or at the foot of the chimney-pot. The buoyancy of the air keeps the bladder continually in a circular motion, and thereby prevents the rush of air into the funnel from descending so low as the fire-place.

SOLDERS, to MAKE:—

Solder for Lead.—Tin, 1 part; lead, 2 parts. Its goodness is tried by melting it, and pouring the size of a crown piece upon the table, and, if it be good, there will arise little bright stars in it. Apply resin when this solder is used.

Solder for Tin.—Lead, 10 parts; tin, 7 parts.

Solder for Pewter.—Tin, 1 part;

weaving. The spokes should be double, and the extra spokes may be inserted beside the original ones, after the weaving has progressed a few rounds. Number 5 reed should be used for the spokes and No. 4 reed for the weavers, which are woven back and forth around the spokes.

Drive the legs into their sockets, applying glue, and pin them with nails, as at H, Fig. 4. Tack strips on the bottoms of two pairs of legs and then fasten two strips to brace them, as shown in Fig. 6. The strips should be put on and the distance between the legs spaced before the glue sets.

It is best to weave the sides before beginning the top, so as to prevent rubbing the woven top while weaving the sides, with the stand inverted. The side spokes should be 2 ft. long and should be set into the top 1 in., with glue. Turn the top of the stand down on a table, and begin the weaving at the under side of the top. Single weaving is used for the sides, every other round passing twice around the legs.

There being four sides in the construction, there will be an even number of spokes, even though there should be an odd number to each side. The weaving would thus repeat itself, in going behind and before the same spoke each time. This is not desirable in this construction, and a change should be made each round. To do this, go over two spokes, instead of one, at the finish of a round. Such a "skip" is an Indian method, and forms a design that may be carried in slanting lines back and forth down the side of the stand. It is best to confine these "skips" to one side. Another way to overcome the repeat, as the weaving in and out around the same spokes in two successive layers is called, is to insert an extra spoke on one side, thus making an odd number of spokes around the stand. It is necessary then to conform the design of the open work for this side to the number of spokes. The design for the open work shown in Fig. 2 will be used for the stand illustrated in Fig. 1, and to be described in detail. The first of the two methods of overcoming the "repeat" will be used.

Insert the extra reed for doubling the spokes, after a few rounds have been woven adjoining the top. The method of weaving from the corner post and the making of the open design are shown in Figs. 7 and 8. The method of "pairing" for winding the reed in and out of the spokes, is shown in Figs. 9 and 10. The rear weaver of the pair of strands is thrown over the forward weaver, back of the next spoke and out. The fore weaver then becomes the rear one, and is thrown in like manner. This process is repeated in order to make the complete rounds. Figure 9 shows the weaving from the side, and Fig. 10 is a view looking down on top of the spokes and the edge of the weaving, shown in section. Pairing gives a continuous rope twist to the two weavers, and an even or odd number of spokes is equally suitable.

For the open designs of Fig. 2, one or more of which may be placed in the side of the stand, the center spokes are left free, as shown in Fig. 7. Before turning the first weaver back for the open work, as at M, start a short weaver N about two spokes back from the opening, and pair it with the regular weaver across the opening, and two spokes beyond. In turning back on the spokes, the single weaver goes twice around the spokes, as shown by the intermediate layers O. This is a short bend and the weavers must be very soft. Use short ones and wet them frequently with a sponge. A sectional view of the weaving at the opening is shown in Fig. 8, as it joins with the weaving around the corner posts. At K, the weaver turns back on a double thickness of reed, and at L, a short spoke is set back of the other two, and the weaver is wound around the three, thus lessening the abruptness of the winding. The latter method is the better. At the horizontal center of the opening, two rounds continue across the opening and around the stand. Pair a short piece of reed across at the finish of the openings, as was done at the lower end at N, Fig. 7.

After weaving to within 5 in. of the bottom of the legs, cut off the extra member of the double spokes, and soak the ends of the remaining spokes in water. Braid them into the border finish, as shown in Fig. 1. The corner posts serve as spoke spaces, and the spokes nearest them are wound around the bottom ends of the legs. Short spokes may be inserted beside the posts and wound around them if the ends of the spokes are not long enough for this purpose.

The top may be made next. Holes are bored horizontally into the edge of the under disk, as shown in Figs. 4 and 11. In Fig. 12 the holes are shown bored into the edge on an angle. This method gives a thicker rolled edge to the top, although both methods are satisfactory. These holes must be bored before the work on the top is begun. There are two ways of beginning the weaving for the top. The radial spokes may cross each other in groups of four, the upper and lower courses being bound together with winding reed, as shown in Fig. 13, or a small maple disk may be used as a lead, 2 parts; bismuth, 3 parts.

Solder for Brazing.—Copper, 3 parts; zinc, 2 parts; or sheet brass, 3 parts; zinc, 1 part. This is called Spelter, and is used for brass, iron and copper.

Solder for Britannia Metal.—Bismuth, ½ of 1 part; tin, 1 part; lead, 1 part.

Solder, Soft.—Tin, 2 parts; lead, 1 part.

Solder, Hard.—Copper, 2 parts; tin, 1 part.

Zinc and lead are soldered with lead and tin, not quite equal parts, lead preponderating.

To use Old Britannia Metal instead of Block Tin in Solder. Take old britannia metal and melt it; and while hot sprinkle sulphur over it and stir a short time.

SOLDERING, Hard.—To braise 2 pieces of iron together, file one side of each piece bright, put on the clean face a paste made of borax and water, tie the two pieces together with several separate coils of brass wire, smearing more borax on these. Hold it over a bright coke fire, and the brass will melt and run into the joint. File off the superfluous metal. When the brass melts a blue flame will be seen to arise.

SOLDERING MIXTURE, for Iron, Steel, Copper, &c.—Take any quantity of muriatic acid, and dissolve as much zinc in it as it will take; then dilute it with ½ as much soft water as of acid, and it will be ready for use.

This applied to iron, &c., cleanses it, and leaving zinc upon the surface, causes solder readily to adhere to it.

SPRAIN.—Hold the part in very cold water for two hours.——Or, apply cloths dipt therein, four times doubled, for two hours, changing them as they grow warm.——Or, bathe in good crab verjuice ——Or, boil bran in wine vinegar to a poultice. Apply this warm, and renew it once in twelve hours.——Or, mix a little turpentine with flour and the yolk of an egg, and apply it as a plaster. This cures in a desperate case.

Weakness remaining after a sprain is cured by fomenting the part daily with beef brine. Suppose the ancle sprained:—1st. Foment it with warm vinegar four or five times every four hours. 2nd. Stand, if you can, three or four minutes at a time on both your feet, and frequently move the sprained foot. Sometimes also while sitting with your foot on a low stool, move it to and fro. 3rd. Let it be gently rubbed with a warm hand at least thrice a-day. 4th. Two hours after every application of the vinegar, let it be just wetted with spirits of wine, and then gently rubbed.

center from which the spokes radiate, as shown in Figs. 14 and 20. The center-disk method is not difficult, and is used extensively. The other type is novel, and also quite feasible.

The spokes for the method shown in Fig. 13 are bound together in the following manner: Place two spokes at right angles to each other and wind them with winding reed, the end of the latter beginning between the two spokes, as shown at P, Fig. 15. The perpendicular spoke is uppermost. Add a second perpendicular spoke and bind it into place, as at Q. Continue this process until four perpendicular spokes have been bound in as at R. Place a second horizontal reed into position and go over each vertical spoke with a separate winding, as in the first course. Continue until four horizontal spokes are bound in, and the end of the winding reed is looped around the last, as shown at S. The spokes should be of No. 5 reed, and 24 in. long.

Four groups of four spokes each will result by following out the process described. Separate the spokes by drawing the outer ones into the corner spaces. They should have the appearance of spokes in a wheel, as in Fig. 16. Use two weavers of No. 4 reed, in the pairing weave, as shown in Fig. 16, and in detail in Figs. 9 and 10. Continue the pairing weave until a center, 8 in. in diameter, is woven. Crowd up the weaving closely, for the appearance of the top will depend much on the first few rounds. Hold the center with the left hand, and manipulate the weavers until they are well seated in their proper places.

When a few rounds have been woven, nail the center securely to its place on the middle of the top. This will leave both hands free for the weaving. After a disk, 8 in. in diameter, has been woven, begin the triple weave illustrated in Figs. 17 and 18. As the triple weave is begun, add another spoke, 8 in. long, between each pair, all around the top, making 16 new and 16 original spokes. When two or three rounds are woven, the new spokes will become secure. Continue the triple weave to the edge of the top. Measure and cut the end of the spokes to uniform length. Curve the ends over the edge to see how much will be needed before cutting, allowing about ½ in. for insertion into the holes in the edge.

Wet the ends of the spokes with water until they are pliable enough for the curve. Bending and tying them down while wet and permitting them to dry in this position, as shown in Fig. 19, is desirable also. Weave down the curve of the roll and insert the ends of the spokes in their respective holes with glue. Then with the single, plain weave on the under side of the roll, weave well up to the ends of the spokes.

For the disk-center method of construction, as shown in Figs. 14 and 20, use ½-in. maple, and cut it 5 in. in diameter for the centerpiece. To locate holes on the edge of the disk draw a line 3/16 in. from the upper edge and mark off spaces 1 in. apart, except four, which are made 15/16 in. apart, to make a convenient division, practically uniform. Bore the holes ¾ in. deep. Number 5 reed is used for the spokes and No. 4 reed for the weavers. The disk should be toenailed around its edge with brads, fixing it firmly to the top before the spokes are inserted.

Proceed with the pairing weave, as in the other method described, until 2 in. of the spokes is covered; then change to the triple weave and add additional spokes. Proceed as with the other type from this point on.

The taboret is braced by two 1-in. dowel rods, placed 2 in. above the bottom roll of the sides and extending from one corner to the other, diagonally. Their crossing at the center may be made into a halved joint, by cutting away one-half of each rod on the adjacent edges. The ends are fitted closely into the corners, and are nailed to the legs.

A taller stand or small table, the side weaving of which has been described as applied to the taboret shown in Fig. 1, is illustrated in Fig. 2. The construction in general is similar. A lighter roll is used for the top, and the bottom ends of the legs are curved outward slightly. The legs are curved by steaming the ends of the corner posts, clamping them into position, and permitting them to dry.

The footstool, shown in Fig. 3, may be made as a miniature stand, with vertical legs, and the spokes set in a circle under the top board. The spokes and weavers will carry the form, if well woven. The stool may also be braced, to withstand hard usage. It should be about 12 in. in diameter at the top, 10 in. in diameter for the body, and 6 in. in height.

The method of forming the opening shown in the side of the taboret in Fig. 1, and the weaving of the construction, will be readily understood from the method described. The principles and methods presented may be applied readily to other construction of the same general type.

TUMOURS, Cure of.—To remove tumours, Dr. Simpson, of Edinburgh, introduces a hollow acupuncture needle, or very fine trocar, into their tissue, and injects in a few drops of some irritant liquid, such as a solution of chloride of zinc, perchloride of iron, or creosote. The effect has been to destroy the vitality of the tumours so treated, and they have been separated. We have seen a similar plan adopted in Paris by M. Maisonneuve. He had slender stylets, made of a paste composed of flour, water, and chloride of zinc. These are baked. A puncture is made in the tumour, the caustic stylet is inserted, broken off, and left. We saw several malignant tumours treated in this manner, and some cases in which a healthy granulating surface was left, after the separation of tumours which had been destroyed in this manner.

WASHING, made Easy.—One of the best bleaching and emolient agents in washing either the person or clothing, is common refined borax. Dissolve in hot water, ½ a lb. to 10 gallons; a great saving in soap is effected by its use. The borax should be pulverized first. It may be procured in the form of crystals at any druggist's; it will not injure the most delicate fabric; and laces or other fine tissues may be washed in a solution of borax with advantage to colour, &c.

WASHING, Ready and Effectual Mode of.—Dissolve 1 lb. of soap in 3 quarts of boiling water, the night before washing. Beginning to wash, put the soap into the dolly tub, add 8 table-spoonfuls of spirits of turpentine, and 6 ditto of hartshorn. Pour upon the above 8 gallons of boiling water. Have the clothes ready assorted; begin with the fine ones. Dolly each lot about 5 minutes, wash them in hot water in another dolly-tub, if you have it, next in blue water.—When the water is getting cool, put it into the boiler to boil kitchen towels, or any greasy things.

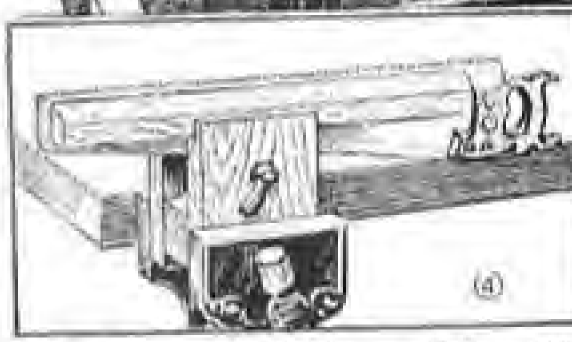
N.B.—The quicker the washing is done the better. As soon as one lot is taken out of the dolly tub, put another in whilst the others are being rinsed.

WATERPROOFING Shoes.—Melt bees' wax and mutton suet, and when you take from the fire, add a tea-spoonful of turpentine. —— Or, India rubber and gutta percha, dissolved in good naphtha.——Or, yellow wax, 4 ozs.; rosin, 4 ozs.; linseed oil, 1 pint; oil of turpentine, ¼ of a pint. Melt over a *slow fire*, and when melted, take from the fire, and add the turpentine, and stir well. Remember that it is very inflammable. When required for use, melt and apply.

WATERPROOF CLOTH.—

From Popular Mechanics 1933

SAW-FILING
A workshop requisite



SHARP saws, kept in good shape, are as necessary to the workshop owner as a sharp knife is in the kitchen. The work is not difficult and nearly every small shop has the facilities needed for doing it. Handsaws, small circular blades, dado heads, back and dovetail saws are easily jointed, set and filed by hand.

In filing various types of blades the procedure must be governed to a certain extent by the condition of the tool. If the saw is being filed for the first time, and has not been damaged in any way, it is likely that a mere touching up of the points is sufficient. Setting the teeth should be done only when necessary. In filing a new saw the first time, every effort should be made to preserve the original shape of the tooth as this is the best guide in filing. The size of the file must suit the teeth, particularly on the crosscut saw, as the number of points to the inch varies with the size of the teeth. A single-cut three-cornered file is most commonly used in filing handsaws and the smaller-diameter circular blades. The points per inch are equal to one more than the number of teeth per inch, as will be seen from Fig. 1. This designation is used only on straight blades.

If the teeth of a hand-saw have been damaged by running accidentally onto a nail or other metal object, most particularly if the teeth have been damaged only on one side of the blade, as frequently happens, it is best to joint the blade lightly before setting. This is done by making a simple holder from part of an old file as in Fig. 8, although a small jointer, as shown in Fig. 5, can be obtained at almost any hardware store. The object in jointing is to bring all the teeth to the same length before filing. Damaged teeth should be given only a light jointing; then they should be set and afterward finished to length by a second jointing. This avoids taking off too much at first which would necessitate undue filing to shape the teeth properly. As a rule, a saw in good condition should be only lightly jointed, then set and filed, but if the set is nearly out of the teeth it is better to set the teeth first, then lightly joint and file them. In every case the procedure must be determined by the condition of the blade. The degree of the set depends largely on the work to be done. If the saw is to be used exclusively on soft wood the set should be sufficient to form a slight space or valley between the alternate teeth. In hardwood, and for average use, the set should be medium. If the saw is to be used exclusively in hardwood, the set should be very light. Fig. 1 shows the approximate degrees of set to meet various conditions. The same is true of both crosscut and ripping blades.

Handsaw blades may be set by using a pin punch, as in Fig. 7, but a saw-setting tool, as shown in Fig. 9, is better as it is possible to adjust the tool so that only about one-third the length of the tooth is bent. In setting with a punch, care must be

Apply to the calico or linen 2 coats of boiled oil, a little rosin or burgundy pitch, and a small quantity of turpentine. Hang up to dry.

WATERPROOF CLOTH.—To 1 oz. of melted white wax add 1 quart of spirits of turpentine; when thoroughly mixed and cold, dip the cloth in it and hang it up to dry.

WOOD, to Resemble Mahogany.—Take two ounces of dragon's blood, (gum tragacanth) break it into pieces, and dissolve in a quart of spirits of wine, to which add a little soda; let it stand in a warm place and shake it frequently; fit for use when dissolved.

Or take four ounces of logwood, and half a pound of madder; boil in a gallon of water, adding a little pearl-ash, and 1 oz. of walnut peeling. Apply hot.

WORMS.—The worms found in the human body are mostly the *ascarides*, the thread worm, infesting the lower intestine, causing much itching and irritation about the anus. The *teres*, or long round worm, generally seated in the small intestines, and stomach.

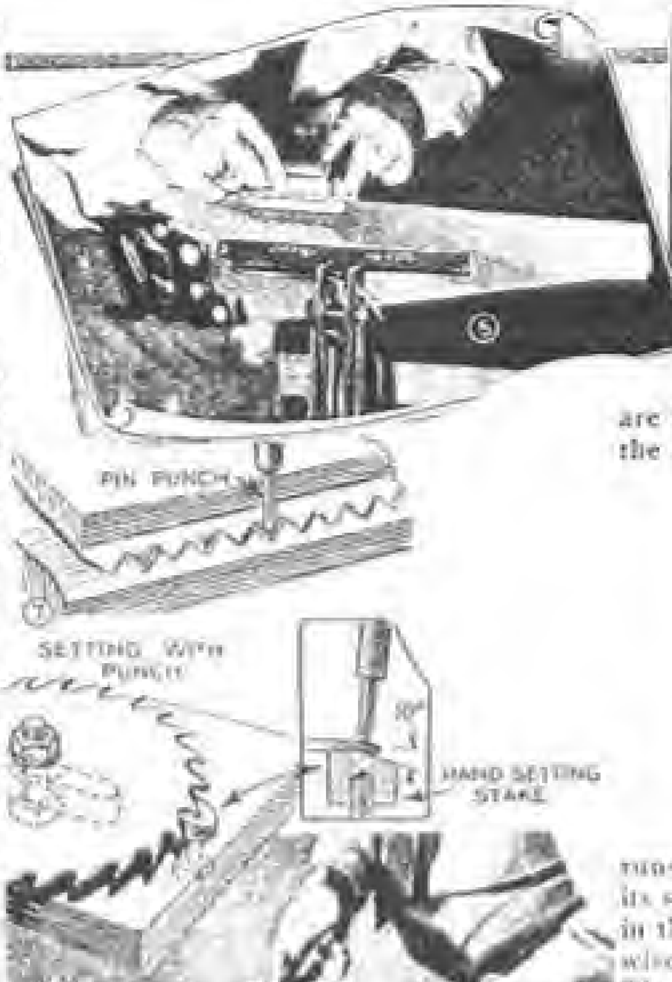
The symptoms denoting the existence of worms are common to the different species, viz. indigestion, with a variable appetite: foul tongue; offensive breath; hard, full, and tense belly, with occasional gripings and pains about the navel; heat and itching sensation in the rectum and about the anus; the eyes heavy and dull; itching of the nose; short dry cough; grinding of the teeth; and starting during sleep, attended often with a slow fever.

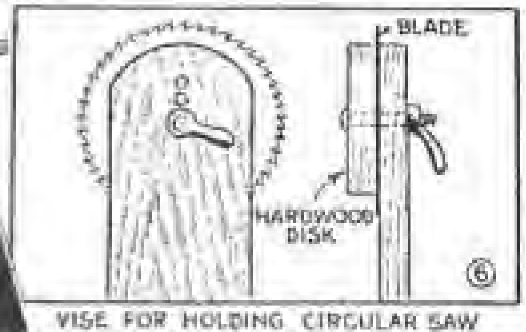
The indications of cure are, first, to clear the stomach and intestines of redundant slime, and afterwards to strengthen the stomach and bowels, so as to destroy the disposition to their generation.

Give an emetic once or twice a week, in order to rid the stomach of impurities, slime and morbific matter, the cause of worms. Attend to the state of the bowels, for they are often irregular through worms. A dose of the Composition Powder given night and morning, and bitter tonics during the day will be of essential service. This should be continued a week or two.

Lime-water being capable of dissolving the mucus in which the worms breed, may be taken; a teacupful two or three times a day—less for a child. Take with it the Tonic Mixture, or bitters. It is very effectual in relieving children.

The following infusion is valuable:—Best senna, Carolina pink-root, manna, worm-seed, rhubarb; of each ½ oz. Bruise them, and infuse for two or three hours in boiling water. Sweeten with treacle. Give to a child six years old from three tablespoonfuls a day.



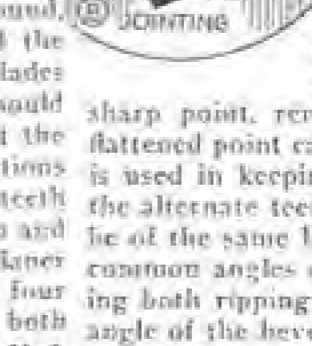


VISE FOR HOLDING CIRCULAR SAW AND DADO HEAD WHEN FILING

taken that the blade is not cracked at the gullets. The hammer blow must be uniform and it is better to go over each set of teeth twice with the saw clamped between two hardwood strips. Circular saw blades, 10 in. or more in diameter, are generally set on a stake made as shown in Fig. 7. Teeth of blades under this size can be set more accurately with the ordinary handsaw set. When starting, see that the tool is properly adjusted by making a trial setting on two or three teeth, then set each alternate tooth, after which the blade is reversed and the rest of the teeth finished. Fig. 11 shows a hollow-ground, smooth-cutting or planer blade and the outside cutter of a dado head. Both blades are hollow ground and the teeth should never be set. It will be noticed that the teeth on the dado cutter are in sections consisting of four or more cutting teeth with a cleaner or raker tooth between and separated by deep gullets. On the planer blade the raker tooth precedes the four cutting teeth in the same section. On both types of blades the cleaner tooth is filed straight across and the best practice requires that its edge be very slightly below the cutting circle of the four crosscut teeth. The inside cutters of the dado head are filed the same as the cleaner tooth on the outside cutters. The cutting teeth on the outside cutter of the dado head are generally in sections of four teeth each. These must be filed the same way, that is, alternate sections of four teeth are filed from opposite sides of the blade, as the teeth of any one section are beveled the same and from only one side.

The circular-saw blade is best jointed on the arbor as in Fig. 10. The blade is reversed so that it runs backward, the table is raised so that its surface is above the cutting circle, and in this position an oil-stone is laid lengthwise on the slot directly over the blade. The machine is started in the regular way and the table is lowered very slowly until the teeth of the saw strike the stone. Care must be taken not to take off more than is necessary. Stop frequently and examine the blade. When every tooth has been touched by the stone the jointing is complete. If desired, a frame to hold the stone can be made as in Fig. 15.

In filing a handsaw it is usually best practice to disregard each individual tooth and adopt a uniform stroke of the file. Though this means that we shall find it necessary to go from one end of the blade to the other several times, the method will produce a job that is nearly perfect, provided, of course, it is done with care and attention to uniformity in the length and number of strokes on each tooth and the angle of the file with the blade. By this method the filing must be continued until the teeth have been brought to a sharp point, removing all traces of the flattened point caused by jointing. If care is used in keeping the file strokes equal, the alternate teeth are reasonably sure to be of the same length. Fig. 12 shows the common angles of the file when sharpening both ripping and crosscut saws. The angle of the bevel on each tooth is determined by the position of the file with relation to the blade, both vertically and horizontally. In this, one should be guided by the original bevel on the tooth, if filing a new saw. The same is true of the



Sweets should be avoided. Salt and water taken in the morning will expel worms, especially the seat worms. It may be made by dissolving a table-spoonful of salt in half a pint of water. It may also form an injection to bring away the ascarides. — Camphor is another remedy. Dissolve 10 grains in a little spirit of wine, and add it now and then to the tonic bitters.

Various Remedies for the Cure of Worms:—

Take an ounce of tin, finely powdered, and two drachms of Ethiop's mineral, mixed together; divide it into six powders, and take one of them, in a little syrup, twice a day: when they are used work them off with a little rhubarb. Or,

Spirits of turpentine, in doses of from 8 drops to a teaspoonful, in gruel sweetened.——Or,

Jalap, ¼ of an oz.; powdered rhubarb, ¼ of an oz.; gamboge, 2 drs.; syrup of bears-foot, sufficient to make it into a paste; then make it into ordinary sized lozenges. Dose:—For a child 3 years old, ½ a lozenge; 6 years, 1 lozenge; and so on, according to years. Or,

Cowhage mixed with treacle. Give a child a teaspoonful fasting for 3 or 4 mornings successively—an adult a table-spoonful. Then give a purge.

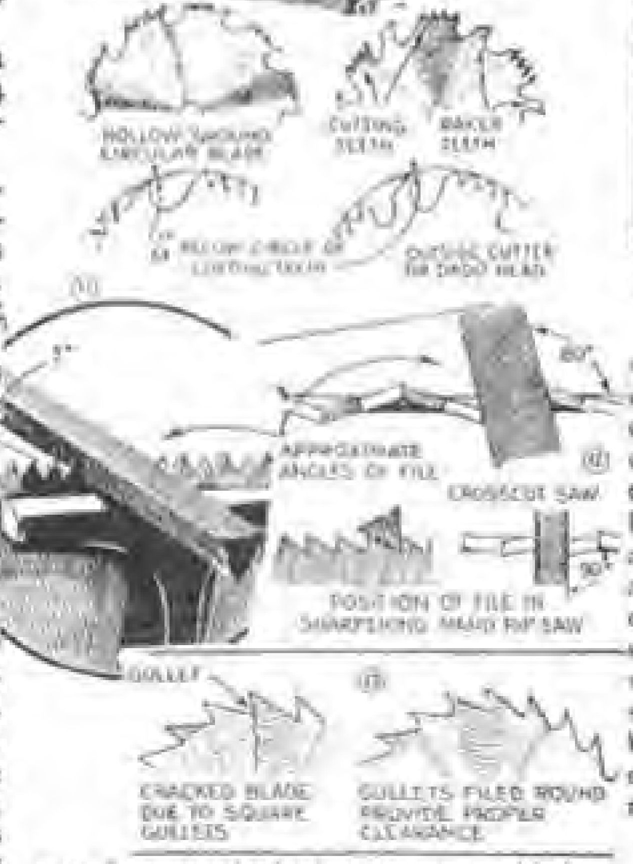
Powdered rust of iron is a good vermifuge. It expels the worms and strengthens the constitution. To a child 6 years old from 10 to 40 grains may be given. An adult may take from a ¼ oz. It may be given in treacle or in beer. Dr. Rush says, "Of all the worm medicines that I have given I know none more safe and certain than this simple preparation of iron." It should always be followed by an aperient.

The common male fern-root is a certain remedy for the *tape*-worm. Two or 3 drs. of the powdered root to be taken in the morning, no supper having been taken the night before. It generally sickens a little. A brisk purgative is to be given a few hours after, which sometimes brings off the worm entire; if not, the same course must be followed at due intervals. For the success of this remedy, the root should be *recently* gathered; as after being kept long in the shops, its activity is diminished or destroyed.

WORMS.—Take 2 tea-spoonfuls of brandy, sweetened with loaf sugar, every morning.——Or, a spoonful of the juice of lemons.

Or, take 2 tea-spoonfuls of worm-seed mixed with treacle, for 6 mornings. Or, 1, 2, or 3 drs. of powdered fern-root boiled in mead. This kills both the flat and round worms. Repeat the medicine from time to time.—*Wesley.*

circular blade. After filing, the teeth of both hand and circular saws should be lightly dressed with an oil-stone as in Fig. 14, to true up any chance inequality in the set, and to make the blade cut more smoothly. The gullets of large diameter ripping blades should be rounded occasionally with a small round file. See Fig. 13. This is known as "gumming," and is



not of any particular importance on blades smaller than 10 in. in diameter. In filing, care should be taken not to run the three-cornered file deeply into the gullet.

Figs. 4 and 6 show vises that may be made from pieces of hardwood to hold both the circular and straight blades for filing. In the case of both handsaw and circular blade vises, the edge of the vise should contact against the entire surface of the saw blade, just below the teeth. In the absence of suitable ready-made vises, as shown in Fig. 3, these homemade ones will serve very well.

Fig. 14. Teeth of Both Hand and Circular Saws Should Be Lightly Dressed Down on the Sides

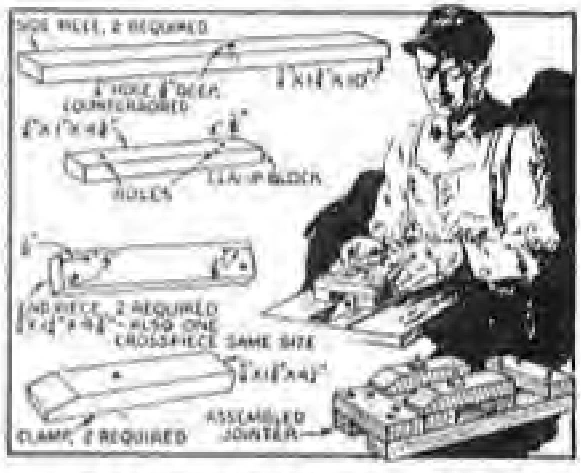


Fig. 15. A Frame for Holding the Abrasive Stone When Jointing the Teeth of a Circular Saw

For those who would like to start a small community repair shop and thus go into the matter of saw filing on a commercial basis, investment in a saw-filing machine will soon repay one for its cost by the saving in time. Such a machine, driven by a 110-volt motor, automatically files and joints rip, crosscut, back, miter, meat and all other types of handsaws, besides circular saws from 3 to 24 in. in diameter, with 3 to 16 points per inch. It is also provided with an attachment for filing band saws from ⅛ to 4½ in. wide. Either a bench or pedestal-type machine can be obtained to best suit the space requirements of your workshop.

An Automatic Motor-Driven Saw Filer for Circular, Band and All Handsaws

YEAST, Dry.—Boil a large handful of loose hops, or a heaped tablespoonful of pressed hops, tied in a muslin bag, twenty minutes, in three pints of water; then take out the bag, and stir into the hop-water a pint of raw potatoes (grated.) Add one tablespoonful of salt, one of ginger, half a cupful of sugar, and one pint of flour; stir the flour in slowly, and pour as much boiling water as is needed to make it a smooth batter, stirring briskly while pouring it on, till all is smoothly combined. Then remove from the fire. When lukewarm add a cupful of good yeast, or one good yeast-cake dissolved. Let it stand one day in warm weather, or two in cold, stirring it down as often as it rises and foams. Then stir in good white corn meal to make it thick enough to make into thin cakes. Dry these cakes in the shade; but where the air circulates briskly, turn them over often. The quicker they can be dried, the better they will be. When dried all the way through, put them into a bag, and hang up in a dry, cool place.

Cakes should be small; not over two inches across, and half an inch thick. One of these cakes will raise four or five good-sized loaves.

YEAST, for Home-made Bread.—Boil a handful of hops ½ an hour in 3 pints of water. Pour half, *boiling*, through a sieve, upon a cup of flour, mix, and add the rest of the hop water; a spoonful of salt, half a cup of treacle, and *when warm*, a cup of yeast.

YEAST, to Make.—Thicken 2 quarts of water, with fine flour about 3 spoonfuls, boil half an hour, sweeten with near ½ lb. of brown sugar; when near cold, put into it 4 spoonfuls of fresh yeast in a jug, shake it well together, and let it stand one day to ferment near the fire, without being covered. There will be a thin liquor on the top, which must be poured off; shake the remainder and cork it up for use. Take always 4 spoonfuls of the old to ferment the next quantity, keeping it always in succession.

A half-peck loaf will require about a gill.

YEAST, to Make Another Way.—Boil 1 lb. of potatoes to a mash; when half cold, add a cupful of yeast, and mix it well. It will be ready for use in two or three hours, and keeps well.

Use double the quantity of this to what you do of beer-yeast.

To take off the bitter of yeast, put bran into a sieve, and pour it through, having first mixed a little warm water with it.

SURVIVING FATIGUE

by
Bill Abreu

An ever increasing problem among many individuals is fatigue. Fatigue has many causes, physical strain being only one of them. However, other causes include: lack of oxygen (as the case may be in higher altitudes), lack of salt, sugar, or water, and high temperatures. Fatigue can also come from a combination of these and other contributing factors.

Firstly, physical exertion does indeed cause fatigue, as anyone who has worked hard for long hours is well aware of. For a long time this was thought to be the only cause. But when studies were made it was found that sometimes people who worked extremely hard felt fine, while others who had worked the same or even less hours were totally exhausted. This at first confused physicians who soon came to realise that fatigue could be brought on by demands, other than physical, which the body makes. Thus the problem is that it is often difficult to recognize exactly what makes you feel tired.

Fatigue is also caused by jobs. Workers get home and feel like doing nothing after dinner but sitting down and watching television. Usually this worker will attribute his weariness to the job itself or the fact that he has been working so hard. Actually most human beings use about one third or less of their full capabilities.

Strange as it may seem, it has been shown that productivity drops when working hours are lengthened. But when they are reduced the rate of production increases, forcing the worker to put more labor into each hour. Interesting to note is the fact that people who work night shifts are usually prone to more errors and will produce less than they would during the normal daytime shift. This is because of a timing device in the human mind called the circadian rhythm which tunes our body functions to the rotation of the earth. It also helps to explain why some people feel more tired in the morning than they did the night before, while others are exactly the opposite. Often, fatigue results when a person exerts himself at certain hours when his body adjustments dictate that he should not. Understanding one's circadian rhythms can be a great benefit to feeling and working at your best. To do so a few simple questions should be answered.

First, take into account how you feel when you get up in the morning, when you go to bed, and at what times. Then decide if this schedule changes when you go on vacation or elsewhere. When do you eat your meals? Are they at strict patterns or at random? Most helpful is accounting the times of day when you usually are the most happy and when you are low.

Sometimes it is difficult to change your ways if there definitely is a conflict in your body clock. It is, however, fairly simple to take certain precautions. Of course, you should avoid any physical or mental exertion at times when you are least productive. If you feel tired when you awake in the morning then you might try waking up or going to sleep at different times. Obviously it is best to do the most important tasks when at your highest peak of the day. Or writing a nasty letter to someone when you feel your worst. If you eat meals at regular set times you can change your eating habit schedule and see if you notice any differences in your highs and lows.

Sleep also has a lot to do with fatigue. A person who has too much sleep may perform just as badly as one who has had too little. At wake up time some people will fall back asleep for those "just few more minutes." This usually results in fatigue and sluggishness for the day because of the fact that their whole schedule has been thrown off. Keeping a regular sleeping schedule so that your body can properly adjust to it is also important. If you decide to try changing the time that you go to sleep, then you should stay with that set time for a few weeks. And rather than hopping right out of bed in the morning at the sound of the alarm, it helps to lie awake for a few moments and stretch or sit up. This will save you from the sudden shock of transferring from a dream state to reality, and allow the blood to start flowing. Instead of coming fully awake at around noontime, you will be most alert in the morning.

Exercise, though it can be a cause of tiredness, can also help relieve fatigue. The best kind of exercise for this reason is one which is not too strenuous. Naturally, after a few sets of tennis you would be tired and worn out, however, a short walk can be especially helpful in overcoming fits of fatigue. For one think, walking gets the blood circulating, allowing more to flow to the brain where it is much needed. Another added benefit of walking is that it relieves strain on the heart. Thirty percent of the circulation of blood is done by the legs when walking. The constant motion pushes the blood upwards through the body and to the heart, reducing the chances of heart problems.

The way you eat can also have a lot to do with whether you feel fatigued or not. It should go without saying that the four basic food groups (milk, meat, vegetables, and bread) are much needed in your diet to eliminate the chances of fatigue due to poor nutrition. But often the problem lies not in the kinds of foods eaten, but when they are eaten. Many people have gotten into the habit of eating very little in the morning and afternoon, and then gorging themselves for dinner. This is not a good practice, for the blood becomes overloaded with calories in the evening, a time when the person will most likely do nothing to burn it off. It has to pump harder to absorb the food, leaving the brain with less blood. This lower amount of blood to the brain causes fatigue and leaves the individual feeling light-headed.

Breakfast greatly affects how one feels during the course of the day. However, the idea that people need to stuff themselves with food in the morning to support them through the day is a misconception. Too much food at any given time again results in the blood having to absorb it all. While it is a good idea to get the requirements in the morning meal, one does not have to eat an entire feast. Vitamin C cannot be stored in the body so a glass of orange juice or a slice of grapefruit should be consumed in the morning. Cereal is also good for people who are trying to keep their weight down, for it contains low fat. Eggs, on the other hand, contain high cholesterol and iron which can be beneficial but should not be eaten in excess.

Another important cause of fatigue is boredom. When a person is bored he may resort to eating or sleeping. There are, of course, other alternatives but these two are the most common. It is no secret that an uninteresting book can make you feel drowsy. And in most cases this drowsiness is unjustified. A person may have gotten plenty of sleep the night before and be feeling just fine in the evening when along comes his neighbor with films of his wife and brats. It is then when the normally alert person must start stifling yawns to remain courteous to his guests.

Monotonous jobs are the major causes of boredom. Even if the job appears interesting at first, it can quickly become dull after being overdone day after day. Some assembly line workers can carry out their jobs and productivity well because they think about more pleasant subjects while working. When finished with their hours it has been shown that they can scarcely remember having worked at all. Daydreaming seems like a no-no while on the job but there is absolutely nothing wrong with it as long as it does not interfere with one's working performance.

The most obvious way to escape job boredom is to get a different job; however, this can often be difficult to do. If this change of occupation is impossible then the alternative of daydreaming may provide a limited relief. During long breaks a short nap can be taken. Though it sounds like a child's pastime, short sessions of sleep can be excellent for recharging one's vitality. When off the job and boredom still occurs exercise has been found to be a good cure. Exercise results in mental alertness and provides the bored person with something to do in his idle time. Again, a brisk walk is the perfect kind of exercise for relieving this boredom.

There are a few simple practices which can be done for fits of fatigue when quick revitalization is needed, such as an upcoming important meeting or party. Lying down with one's feet elevated for a few minutes can sometimes increase consciousness by providing less blood for the legs and more for the brain (though the temptation is great, it is wise to avoid closing your eyes when doing this). Boredom often comes from those who use their minds for countless simple and menial tasks. Enrolling in certain community groups or school classes will relieve the effects of boredom and supply the individual with something more important to do other than deciding what to watch on television. Niacin (as mentioned in issue 6, volume 2 of The Survivor) can be helpful against fatigue, in that it opens wide the vessels and capillaries and allows blood to flow (which, incidentally, explains the flushing sensation).

When times get worse and you must adjust to a different kind of living, fatigue may be a major problem. But, as of now, it is simply one which must be overcome like the many others that exist in these troubled times.

DOUBLE ROOFS PROVIDE IDEAL SHADE FOR POULTRY COOPS

From Popular Mech. 1919

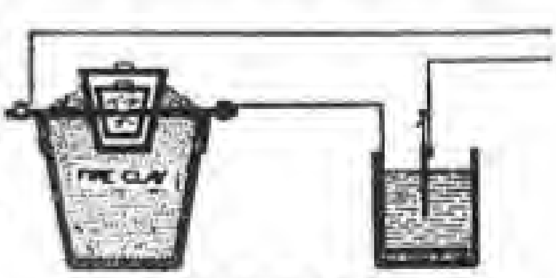
Having no native shade in our city chicken yard, we noticed one summer that the hens, especially those in the low brooder coops, became droopy and exhausted from the excessive heat. We studied the construction of the U. S. Weather Bureau thermometer shelter, which usually stands out in the sun, and is no larger than our brooder coops. It has a double roof with free air-circulation space between the roofs, hence the inclosed thermometers are exposed to a true-shade temperature. We then placed an extra roof on each of the brooder coops, leaving a 6-in. open air space between, the top roof being supported at the corners only. The arrangement proved so effective that the hens sought the coops, against the heat of unventilated inclosures on quiet, hot days.

How to Make a Small Electric Furnace

From Popular Mechanics 1915

The furnace consists of a large flower pot containing an ordinary clay crucible about 6 in. in height, the space between the two being packed with fireclay. Two ¾-in. holes are bored through the sides of the crucible about half way between the top and the bottom. Holes corresponding to these holes are molded in the fireclay, which should extend several inches above the top of the flower pot. A smaller crucible is placed inside of the large one for use in melting such metals as copper, brass and aluminum. With metals that will melt at a low degree of heat, such as tin, lead or zinc, the large crucible can be used alone. Each crucible should be provided with a cover to confine the heat and keep out the air. The electrodes are ordinary arc-light carbons.

The furnace is run on an ordinary 110-volt lighting circuit and it is neces-



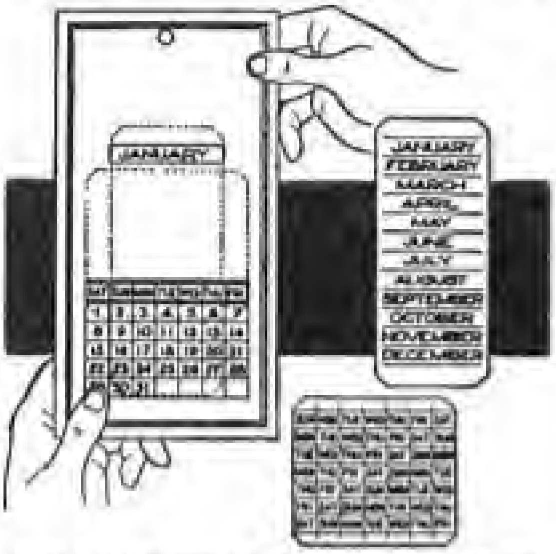
Electric Connections to Furnace

sary to have a rheostat connected in series with it. A water rheostat as shown in the sketch will serve to regulate the current for this furnace. Small quantities of brass or aluminum can be melted in about 10 minutes in the furnace.—

A Perpetual Calendar

From Popular Mechanix 1919

It is only necessary to set this calendar the first of each month, by sliding



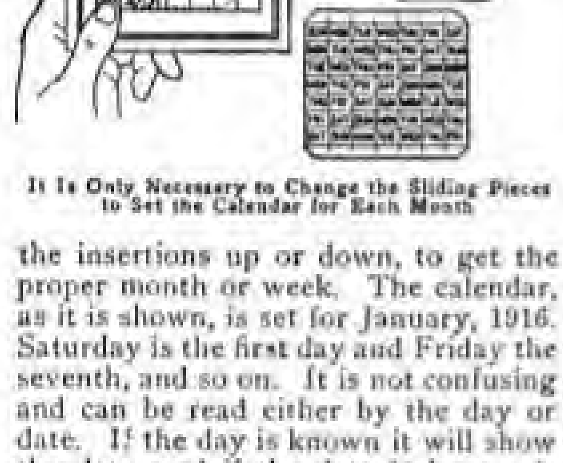
It Is Only Necessary to Change the Sliding Pieces to Set the Calendar for Each Month

the insertions up or down, to get the proper month or week. The calendar, as it is shown, is set for January, 1916. Saturday is the first day and Friday the seventh, and so on. It is not confusing and can be read either by the day or date. If the day is known it will show the date, and if the date is known it will show the day. The illustration clearly shows the parts, which can be cut from heavy paper or cardboard.

Making a Catamaran Raft

From Popular Mechanics 1925

A simple raft, that will meet the requirements for an inexpensive and simple



A Useful Boat, Built of Logs as a Catamaran Raft, Takes the Place of a Regulation Rowboat When the Latter is Not Easily Obtained

boat, can be made from two or three logs in the manner indicated in the drawing.

Two logs, about 12 ft. long, are used for the sides, and connected with crosspieces, spikes or wooden pegs being used to secure the parts together. A piece of split log answers for a seat, and two forked branches, inserted into the sidepieces, make satisfactory oarlocks. In the absence of regulation oars, pieces of board can be cut to approximately the proper shape.

SELF EMPLOYMENT FOR ANYONE

By Kurt Saxon

There is something about working steadily for someone else that dulls the human mind. Security is the main reason people give for fixed employment but the unrealized drawback is dependence.

With fixed employment you have a measure of security only if the business is growing. You may even advance, getting higher wages. But when the business levels off, so does your pay. And as the pay scale becomes fixed, so does the routine. So you are at a dead end and become just a part of the machinery.

A worker can go for years doing the same thing and getting the same pay. Except for cost-of-living raises, which seldom make up for inflation's gain in the same period, spendable income remains about the same.

When a business hits its peak and is serving as big a part of its market as it can reach, it usually starts going downhill. This is because the market has been saturated. There is no more room for development, no new money coming in.

Then, even cost-of-living raises are hard to come by. Then come the strikes. Raises are given, prices of the products are raised, fewer people can buy and less money comes in. As inflation eats into your strike-won raise, you must strike again, get the prices raised, lose even more customers and on and on.

That's the way it's getting to be all over the country. So if you work for others and think you have security, you may be insane. You'd better check that out.

The main drawback of a fixed income is your dependence on things staying as they are. Rising inflation and increasing bankruptcies are threats to just about every wage-earner's livelihood.

My early career was wasted in wage-slaving. I was uneducated, unskilled, unbalanced and a drifter from job to job. I could never keep a job long but the worst times were when I had a job I could do and stuck at it for up to a year. This was a waste of time as my savings never equalled the price of anything worthwhile.

When I was going to college I worked part time at a hospital doing kitchen duties for $27.00 per week take-home. This was in 1960 and my rent was only $6.00 per week for a room with sink and a hotplate. I spent maybe $3.00 per week for food so I didn't need much.

Just the same, the hours were from four to eight p.m. and I didn't like the work or the money. But a full-time job would have kept me out of college.

I was bitching to a wino name of Charles who lived in the same rooming house. He was a house painter and suggested I get in the trade. I'd never painted but had seen him at it and figured if he could do it, anyone could. I had watched him on a ladder once, hanging on with an elbow, with a fifth of Thunderbird in one hand and a brush in the other. He fell often but worked when he wanted to.

He wrote an ad for me: Painter; Fast, Reliable, Good References, $2.00 per hour and the rooming house phone number and who to ask for. It cost me about $3.00 to run it a week in the Work Wanted section of the local paper under PAINTING. Then I quit my job and sat back. I had to because I'd have been at work when anybody called. It's dumb to quit one job before getting another. So if you work, put in the ad the time you will be home to accept calls.

That lying ad took effect the first afternoon it ran. I got a call from an old lady with a tiny kitchen. I told her over the phone that for $2.00 per hour I'd supply the labor and the tools but she'd have to buy the paint. She had the paint ready and I stopped by the Dime Store and bought a paint roller, pan, three different sized hand brushes and a plastic drop-cloth.

I took this on the local bus and started my first paint job. The old lady showed me into her dark red kitchen and pointed to the bright yellow paint and went into her front room to watch TV.

I poured too much paint in the pan and just dipped in the roller, as the pan

Homemade Shower Bath

A Shower Bath That Costs Less Than One Dollar to Make

While in the country during vacation time, I missed my daily bath and devised a shower bath that gave complete satisfaction. The back porch was inclosed with sheeting for the room, and the apparatus consisted of a galvanized-iron pail with a short nipple soldered in the center of the bottom and fitted with a valve and sprinkler. The whole, after filling the pail with water, was raised above one's head with a rope run over a pulley fastened to the roof of the porch, and a tub was used on the floor to catch the water. A knot should be tied in the rope at the right place, to keep it from running out of the pulley while the pail is lowered to be filled with water, and a loop made in the end, which is placed over a screwhook turned into the wall. If the loop is tied at the proper place, the pail will be raised to the right height for the person taking the shower bath.

The water will run from 10 to 15 minutes. The addition of some hot water will make a splendid shower bath.

Device Enables Crosscut Saw to be Used by One Man

From Popular Mechanics 1925

A device which enables one man to use a crosscut saw is shown in the illustration. Two posts are driven into the ground about 6 ft. apart. Near the top of each of these is fastened a pulley, and midway between the posts is fastened another pulley, as shown. A sawhorse is placed beside one of the posts, the handle

was too full to allow rolling the roller on the pan's ramp. This doesn't work and it was several tries before I got the idea of pouring some paint back into the can and rolling off the excess paint on the pan's ramp before rolling it on the ceiling.

You can't imagine the mess at the beginning. I had paint on me and had a totally yellow arm and a soaked torso through my shirt. If that sweet old soul hadn't been in the front room watching TV, she'd have fired me in the first five minutes.

I'm pretty smart so I got the hang of it in the first half hour. I did that little kitchen in four and half hours and got $9.00 and even compliments.

A few days later this pervert called me and asked if I'd paint bare-chested. I was pretty naive and didn't understand and told him that I wouldn't consider painting bare chested as I got enough paint on my chest as it was without painting shirtless.

That first week I painted two kitchens, a garage and a bedroom. After awhile I seldom had to put in an ad. I got a lot of repeat business and, working only when I wanted to, averaged $34.00 per week. That wasn't much, even in those days. But it was more than I had gotten at the hospital and in fewer hours and was sufficient for my needs. If I wanted something more, I'd just work another day or two. So even in this poor trade my income wasn't fixed and I could choose my hours. I could have worked all the time if I'd wanted to.

Just in case you might want to try this, here are a few tips. Get a book on decorating and study the painting section. Then go to a paint store and have a clerk tell you what you'll need. Your ideal start would be to paint as much of your own home as you can for practice. A couple of days painting your own quarters would get most of the bugs out of your technique.

Charge about a third of what a Union painter gets. Don't worry about Union interference. People who hire bargain painters want bargains. They won't pay Union rates and so don't really expect Union skill. Union painters wouldn't be interested in such jobs, anyway.

Three dollars an hour for non-professional work is fine, especially since you don't have to declare it for taxes. It's all yours unless you want to pay taxes on it. Most of the guys I knew in the trade never declared their income because there was no way the Feds could check.

No matter what, do as good a job as you can and be extremely honest. I was never asked for a reference but those who I would have used as references hired me for one job after another. These were mainly landlords who hired me to redo vacant apartments.

After a time I charged $2.50 per hour and could have gotten more had I become a contractor.

Never work for a non-union contractor. You won't be fast enough to make a profit for him and he'll fire you. If you are fast enough you might as well be a contractor yourself.

Contracting is where you give an estimate and accept a set fee for the job. When people asked for an estimate I would say I needed a license to be a contractor so I just charged by the hour with no estimates. I didn't have the kind of mind where I could examine a job and tell how long it would take.

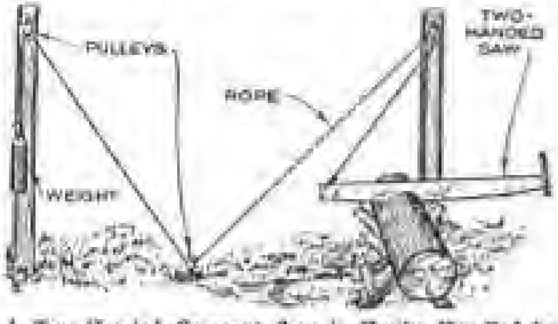
Contracting is more profitable, and I'm not sure about the license, but when you make an estimate, you're stuck with it. If you estimate a job will take eight hours and it drags out to sixteen, you'd be better off working by the hour.

I worked this way, off and on, for years. I was temperamentally unsuited for steady work. But I could be charming and polite to anybody for a few days, which kept me a fine fellow through most of my bigger jobs. Most of my customers were very nice and liked my work, although I was never really fast.

If I could do it, you can, too. You'd be surprised how much work goes begging because unskilled people don't know they could do it and skilled workers price themselves beyond the property owner's means.

Work in painting, home repairs, etc. is all over the place and you'll learn this if you'll only put in an ad. One place I was painting at, there was this young removed from one end of the saw, and the end of a rope passed through one of the bolt holes and tied.

The other end is passed over the pulley on the first post, under the center pulley,



A Two-Handed Crosscut Saw Is Easily Handled by One Man If This Rigging is Used

over the pulley on the other post, and a heavy counterweight is then fastened to it. With this arrangement, the saw may be easily handled by one man.

PAINT MADE FROM POTATOES

From Popular Mechanics 1931

Potatoes provide the base for a cheap and durable form of paint suitable for use particularly on farms for gates, fences or machinery exposed to the weather. One pound of potatoes are peeled and well baked. They are then mashed in three or four pounds of boiling water and passed through a sieve. To the mixture is added two pounds of powdered chalk mixed with four pounds of water. This forms a sort of glue capable of receiving any kind of color, even powdered charcoal or soot for a fine black.

PLANTS GROWN IN AIR-TIGHT BOTTLES

Popular Science 1936

RAISING plants on synthetic soil in bottles sealed against outside air, moisture, insects, and plant parasites, is the remarkable accomplishment of a Millburn, N. J., woman botanist. The artificial soil, which provides a scientifically balanced food for plants, consists of agar-agar, a seaweed derivative, combined with various chemicals. Poured into bottles, it congeals into a translucent, gelatinous mass. Seeds and spores are planted with a platinum needle and the glass containers are sealed with cotton wadding. In their individual sterile "greenhouses," the seeds rapidly develop into healthy, thriving plants. A moist atmosphere containing the essentials for plant life is maintained through the agency of the chemicals and the plants themselves; with each change of temperature, mist forms inside the glass and "rains" back on the plants. Given sufficient light, the plants will grow for years, or until they are too big for their containers, when they can be transplanted to larger bottles or to an outdoor garden. Delicate

moron also doing painting on a picket fence. He didn't even scrape off the old, loose paint.

I noticed he had wet his pants and asked the lady how such a nebbish could get work from anybody. She said he only charged $1.50 an hour and did all sorts of little odd jobs. This was mainly for old people who simply couldn't handle any sort of labor and preferred a mental defective to no one at all.

I met many other odd-jobsmen. They started out just as people who could do something, or were willing to try. They simply advertised that they could do a certain job and they had been busy ever since.

It doesn't matter what you do. Painting, hauling, odd jobs, home repair, carpentry, electrical work, typing, babysitting; a few lines in your local paper will keep you busy. An old fellow who was going with my mom had been a painter. He told me he had worked my system all during the depression and had always lived well.

It isn't all roses. You'll get an occasional griping, abusive customer you can't please. Then there are those who'll want you to be licensed, bonded, insured and all that. If you do your best at say, $3.00 an hour, they're getting a good deal. If they don't appreciate that and give you a hard time, to hell with them. They're stupid. But this type is rare. Most of your customers will be just good, poor people who need a bargain and have sense enough not to give a bargain like you a hard time.

If you happen to be a professional and a Union tradesman, this sort of work would be moonlighting. I knew professionals who cut their pay by a third to be independent. A Union painter or electrician would contact apartment house owners and be on call all the time. No need to worry about licenses. If you're giving a landlord a bargain, he's not going to turn you in to the Union or the licensing place or the IRS or anybody.

So if you are temperamentally unsuited for steady work or have been laid off or fired, put in an ad. Even if you're in fine shape and just need some extra income, put in an ad. If employed, you can tell a caller you'll be free on the weekend or at night. They don't care when you work if it's convenient for them.

You try getting work this way, even if you have a job, and you'll be surprised how needed you really are. You'll never be worried about unemployment again and the worse the economy gets, the more secure you'll be. Places have to be kept up and if money is tight, Union workers stay home.

Another good point is that while you're working on such jobs you are still free to follow up leads on better opportunities. You can also go to school or work on some home business that you don't expect to make money on for awhile. So if you are too young for steady work, retired, slightly handicapped, a dingbat, have a rotten work record, or whatever, you are still highly employable in this field.

Bottled plant, in "rainstorm" caused by the condensation of moisture

Woman botanist using a photometer to check the light conditions for plants in synthetic soil and rare plants are said to be easy to raise by this method and when transplanted outdoors, they prove exceptionally hardy. Because the chemical soil is nearly transparent, botany students can observe and study all the stages of root development.

Moth Balls on Roosts Keep Lice Away

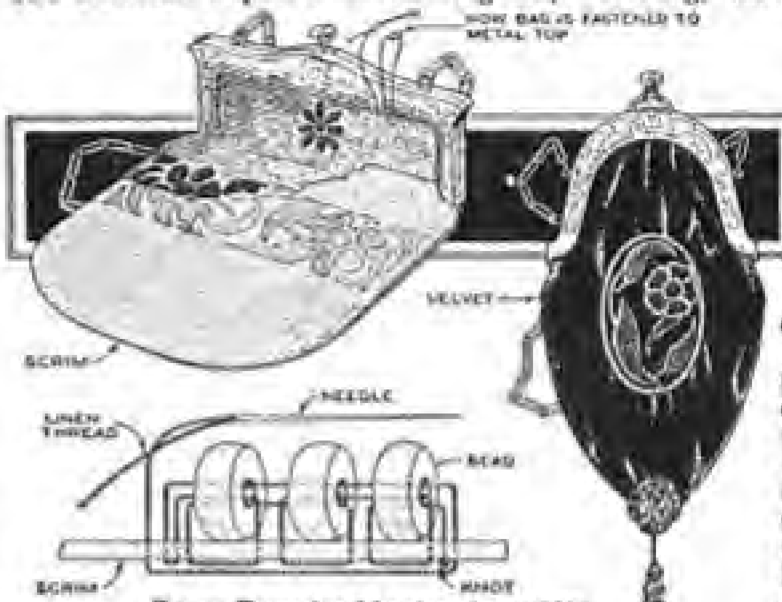
From Popular Mechanics 1931

Moth balls have been found highly effective in keeping lice out of a poultry house. The roosts were fitted with blocks, each of which accommodated just one hen and thus prevented crowding. A hole, large enough to receive one moth ball, was then drilled in each block and also in the roost between the blocks, as shown in the drawing. In attaching the blocks woodscrews were used, these being driven in from the underside of the roosts. It seems that lice cannot endure the strong odor of the moth balls.

Moth Balls Held in Holes Drilled in Roosts Keep Lice Away from Hens

Making Beaded and Velvet Handbags

Beads have been used by woman for thousands of years, and she has not yet wearied of stringing beads on threads and applying them to a background to form various articles of use and ornament, such as the attractive beaded handbags that are at present so popular and —so expensive. However, there is no obstacle to prevent anyone making her own bag at a cost of only the trifling sum required for materials and time. The materials required for the bag are, a metal top, which may be obtained from most stores, ¼ yd. of scrim, lining material, and the necessary beads. In making the bag care should be taken to have the lines of the scrim run up and down, as these lines serve as guides for sewing on the beads.



From Popular Mechanics 1925

METHOD OF FASTENING BEADS TO SCRIM

Beaded Bags are So Easily Made That No Woman need Deny Herself the Pleasure of Owning One. The Decorations may be Worked Out to Suit the Individual Taste

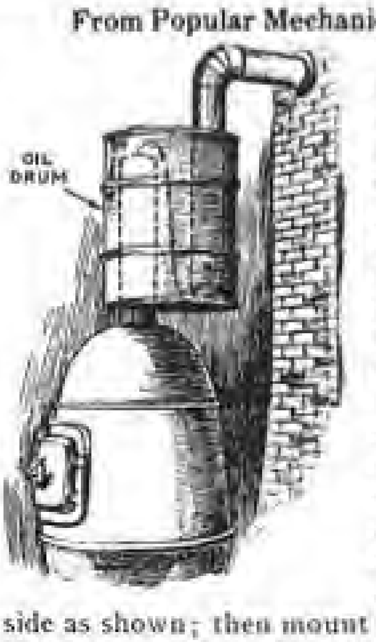
Make an accurate design of the pattern to be reproduced, on tissue paper, and trace it onto the scrim with a "4H" pencil, a hard pencil being used to prevent blurring. After the design has been traced, it is filled in with water-color paints as nearly as possible the color of the beads used.

The beads are sewed on one at a time, guided by the lines of the scrim. Linen thread should be used; this is knotted, and the needle is drawn through from underneath, taking a bead of the proper color on the needle. As shown in the drawing, each bead is securely sewed to the fabric. About every third bead the thread is taken back through them in the manner shown; this makes the bag stronger and the row straighter. It is necessary to make each row straight across, working in beads of each color as it occurs in the design traced on the fabric.

Another effective and pleasing bag consists of colored-bead designs applied against a background of dark velvet, or satin. As it is not possible to trace the design on the surface of these materials, the pattern is applied to the underside of the cloth, and is then worked out with colored threads, which gives the worker the necessary guidance, the beads being applied as described. Instead of using beads, the same idea can be pleasingly worked out in cotton yarns of different colors. The design in this case is traced on tissue paper sewed to the material at the exact location, and the yarn is applied through the paper, which is torn off when the work is finished.

Getting Extra Heat from the Stovepipe

From Popular Mechanics 1931



Usually the heat passing through the stovepipe and chimney is practically wasted, but with the arrangement shown in the drawing much of it is radiated into the room. Take an oil drum and put two lengths of stovepipe inside as shown; then mount the drum over the stove, and brace it to obtain the necessary rigidity. The path of the smoke and hot air through the drum and up the chimney is indicated by arrows.

BARKLESS DOGS BROUGHT FROM AFRICA

Popular Science 1936

These four dogs are of an African breed recently brought to England. They are never known to bark

MUTE but far from "dumb," four voiceless hunting dogs, the first of their breed ever to be seen in England, were exhibited at a recent international kennel show held in London. Short-haired and with sharply pointed ears, the curious animals have never been known to bark. The dogs are called "Basenjis," and were imported from Africa, where they are used for hunting by some of the remote tribes inhabiting the central part of the continent.

Survival Tools

By T. Fitzgerald

The most basic and deadliest weapon ever known is, of course, the human mind. It has the capacity to turn even every-day items into devices capable of maiming and killing, whether in defense or offense.

Beginning at a lower level we will consider ways of using simple and often disregarded items for food gathering and/or defense/offense in an environment of complete collapse.

Several years ago a railroad surveyor was checking a section of track in the Rocky Mountains. He was alone with no weapon. Upon rounding a curve in the track he found himself facing an angry Grizzley Bear. Faced with almost certain injury or death, this man killed the bear in two minutes without injury to himself. How? Very simple. The trackbed was of stones approximately two inches through. He blinded the bear by throwing stones, keeping out of reach meantime, and then proceeded to stone the bear to death. This man was lucky, the next man who tries this may well be killed instead. It does prove, however, that no man is ever unarmed: he only thinks he is.

The stone is probably the oldest weapon in the world. Some of its advantages are choice of size and shape, readily available, unlimited quantities. Also it comes in many styles: The brick or half-brick is probably the style most familiar to city-dwellers. The manner of use is still the same.

Some disadvantages of stones as weapons are they are short range weapons, they come in sizes too big to throw and sizes too small to do any good, and they can be thrown back at you, possibly by someone with better aim than you.

Large stones are good for defending heights as they can be simply dropped and stones too large to be thrown can thus be used. It is very difficult to throw a stone of any size back up at you to any advantage.

To attain any distance and real force with a stone the thrower must have assistance. The throwing weapon PAR EXCELLENCE and of undoubted age is the sling. The classic example is David and Goliath.

There are two basic types of sling. The first is two straps of flexible material (leather boot laces are excellent) joined by

a pocket. The projectile is placed in the pocket, the two ends are held in the hand and the sling whirled round and round the head. At the right moment one strap is released (often there was a loop on the end of one strap to go over a finger), the pocket opens and the stone hopefully flies to the target. Actually, with practice this can be a very accurate and deadly weapon. Depending upon the length of the straps, the projectile, and the method of whirling and release, the extreme range of this type of sling can exceed 300 yards. The ancient Romans and Greeks cast lead sling balls in order to increase the range of their slings as war weapons. These balls often had such mottos as "take this" inscribed on them.

The second type of slings involve a staff or stick. There are two main types of staff slings. The first having a staff about 4 feet long. One strap of an ordinary hand sling is attached to one end of the staff, the other strap being made long enough to be held with the butt of the staff and thus give an extra length to the outside curve of the swing and so give more velocity to the projectile.

Another type of staff sling, employed mainly in military service, was a stout staff with the pouch held securely to it by one strap a few inches from one end. The other strap was fitted with a ring which slipped over the point of the staff. With a stone or ball in the pouch, the staff was held in both hands and swung from behind straight over the head just like driving a stake with a sledge hammer. At a certain point the stone shot forward forcing the ring off the end of the staff and opening the pouch.

A modern sling is of course the slingshot which propells a ball by the force of rubber bands.

Any of these slings is an excellent means of providing meat for the pot with almost no noise and NO expenditure of possible irreplaceable rifle or shotgun ammunition. With the exception of the modern slingshot they are also proven in battle.

Probably the second weapon that man discovered on his way down from the trees was the club. At first merely a broken tree limb it later evolved in many ways.

Wooden missiles have been used as serious weapons of war and effective hunting weapons since prehistoric times and, in isolated parts of the world, continue to be used still.

There are two basic kinds of wooden missiles. The first is the straight club variety, generally with a large knob at one end, which is thrown and is meant to stun or kill with a blow. Of course, these can also be held and used to strike blows in the classic manner of a club or bat if the enemy or quarry is close enough. These straight clubs ranged from 3 foot long types used by West African natives to break animal legs at a few feet distance to the clubs of Fiji, about 18 inches long with heavy knobbed ends.

The African KNOBKERRI was the most popular of the throwing clubs, being about 2 feet long, with a narrow rod-like handle. These could be thrown with great force and accuracy. These were used with great effect against Hyrax (Rock Rabbit) and PAUW (a quail-like bird). Two hunters moved about 50 yards apart. As they roused their quarry they threw their clubs so that in dodging one club the quarry almost always was hit by the other.

The native Australians practiced throwing their clubs so they struck the ground several feet in front of an enemy and bounced up, thus being harder to dodge than if thrown straight at the target.

The second club variety is the curved clubs, which if flattened and properly shaped can fly in a variety of courses and even return to the thrower. The common name of such an interesting weapon is the boomerang.

Contrary to popular belief such curved throwing sticks, even the returning type, are not strictly a product of Australia. The word boomerang, strictly speaking, applies only to the curved wooden Australian throwing sticks, but are now used to describe any flat, curved throwing weapons, for sport or war, that can or cannot return to the thrower.

The true boomerang that returns must be thrown with a great jerk to give it a spinning motion. When the forward motion dies, if the boomerang is still spinning fast enough, it will slide backwards through the air, often behind the thrower. This violent jerk when throwing causes an accuracy and velocity loss. Therefore, the returning boomerang is seldom used for anything but birds and exhibitions. The thrower also is in great danger when one returns as it is still spinning fast enough to injure or even kill if a person is hit in the head.

Actual shapes, weights, and sizes are actually just a matter of choice. The light return boomerangs have been thrown as far as 50 yards. Heavier, curved, throwing sticks, meant only for hunting or war and not to return, have been known to break bones and have a range of up to 150 yards. Each individual stick has its own characteristics when thrown and must be thrown in the same manner each time to fly the same. One stick may fly straight for 50 yards and suddenly dive down, for example. This means that there is not as much danger in an enemy throwing such a stick back and causing you injury as you may have thought, because he would not know how to properly throw your personal throwing stick.

In India both iron and wood boomerangs

were widely used.

In ancient Egypt boomerangs are known to have been used as far back as 4000 B.C., generally as sporting weapons for wild ducks, but also as a fighting weapon. A type of boomerang sharply curved on one end is still used in Abyssinia and the Upper Nile.

The Hopi Indians of the American Southwest also had their own version, known as a rabbit stick, for its principal target.

SURVIVAL TOOLS - #3

T. Fitzgerald

Next up on the list of weapons is the spear.

With the end of a stick pointed and hardened in a fire, prehistoric man was able to inflict effective wounds in a large animal, or in his fellow man. Later refinements were stone or bone tips, then metal.

One very important contribution to the development of the spear is a stop, or crossbar, behind the point. This prevented the spear from penetrating too deeply in a large animal, thus putting the spearer into range of the teeth, claws, antlers, or whatever, of the spearee. The spearmen could thus hold on to the end of the spear to fend off his opponent until it dropped from loss of blood or the hunter's companions finished it off.

Spears for hunting gradually evolved until they were perfected in the sixteenth century. Hunting spears were between 6 and 7 feet long, with a blade of 12 to 18 inches long and were used for all types of game, bear spears being larger in all proportions. Animals were either hunted down with dogs or driven into nets. Sixteenth century hunting spears were also well regarded as military weapons.

Lance and spear were originally interchangeable generally, but from the seventeenth century on, lance usually applied to a spear with a long shaft and small head. Today regarded primarily as a war weapon, from early times it was often used for the hunt. As a hunting weapon the lance had limited uses. It could be counted on for a certain kill only on small game, but it gave a horseman a better chance of reaching and slowing down the quarry so a sword or spear could be used.

Spears and lances were of various lengths, to over 20 feet long. The long spears and lances were at a decided disadvantage in bushes, trees, and high grass. Eventually a short spear, 6½ feet long, with a stout staff with a lead weight on the butt, was evolved. These were normally used on a horse and properly used could bring down a powerful animal, but brought the quarry dangerously close to both horse and rider.

Throwing spears, also called javelins and darts, were short, light spears that have always been hunting favorites. Often they had feathered tails, like an arrow, to insure additional accuracy. Top darts were also thrown from the top castles of naval ships. Throwing spears were usually from 3 to 4 feet long with a blade 4 to 7 inches long. The shafts were usually wood but all steel models were popular. The range of most throwing spears was probably 50 to 70 yards, but a French traveler in Persia in 1670 claims distances of "six or seven hundred paces."

To enable all but the heaviest of spears to achieve respectable distance an artificial aid, known as a spear thrower, is needed. The simplest is a loop attached to the shaft. The spear was rested in the hand and thrown by the first 2 fingers hooked through the loop. A similar loop was used in some areas that slipped off the spear as the spear was released. Another type was strap with a loop to fit the butt of the spear and the remainder of the strap wound around the shaft. The free end of the strap was grasped and when thrown, the spear was given a spin, supposedly contributing to accuracy as well as distance.

Light throwing "arrows" are used in England for distance contests only, and have little or no value except for amusement. To throw them a loop that slips off as the arrow is released is used. The record throw for this type of throwing spear is over 372 yards. A regular arrow can be thrown by this method 200 yards easily.

The most effective and efficient spear thrower was the throwing stick* found in Australia, Central America, and the Arctic. Almost all were of wood, between 1½ and 2½ feet long, and many were carved. The basic design is a flat board with a grip at one end and a projecting pin or tooth at the other end. The spear was placed along the stick and held by the fingers, the butt of the spear placed at the pin. With the throwing stick the force of the throw was at the butt of the spear, in many cases doubling the range of a spear. Some Australian aborigines reached distances of almost 100 yards. The Australian spear thrower was normally fashioned in a long bowl-like manner to enable it to be used as a holder for berries and other food stuffs.

Spears with multiple points were also made. The only real value of these pieces seems to have been as fishing spears and for use as frog stickers.

Harpoons are a specialized type of spear used for such activities as hunting whales, seals, walrus, polar bear, sometimes deer, driven or found in the water, and hippopotamus. I doubt there will be much call for harpoons and harpooners.

*Throwing stick called an "atalatl" (Eskimo work) B.S.

SURVIVAL TOOLS - #4

T. Fitzgerald

The rope or creeper noose has been a hunting weapon since man became man. Set up or suspended in the trails of wild animals, attached to the end of a long rod for birds, or even for fishing, it was the cheapest, the simplest of hunting tools, and often the most successful. Early American Indians were prone to capture deer by a loop in the deer trails and lighter rope or cords served both Indians and early settlers for providing the main ingredient for rabbit stew.

To be able to move and give range to the noose the lasso was devised. This is merely a rope with a loop on one end and is now normally thrown from horseback. American Indians were known to use a lasso from a canoe on deer found swimming in lakes and rivers. The Roman mosaic at Utiqa shows a hunter on horseback lassoing a stag. Pictures on Scythian amphora (jugs or jars) found at Chertomlyk show Scythians breaking-in horses using lassos.

From time to time the lasso has also been a successful war weapon. The Sagartians carried no weapons except daggers and ropes made of twisted thongs. When they engaged their enemies they threw out their ropes, with nooses in the end and whatever anyone caught was dragged toward them and, man, or horse, was put to death. One of the "five weapons of war" in the Sinhalese MAHAWANSO was a rope with a noose, running in a metal ring.

Whatever its use in war, the lasso is primarily a hunting weapon. It has been used as such in almost every country in the world. Scandinavian and Lapp hunters have relied on it for capturing reindeer and bear; American hunters have taken mountain lions with it; early Californians were known to rope bears; in Southeast Asia heavy lassos are used in capturing wild elephants; and some cowboys of the old west tried to rope anything they thought no one else ever had. It was in the American West and the Pampas of South America that the lasso actually became famous and it is still used there for controlling horses and cattle.

The American lasso is from 45 to 60 feet long, made of horse hair, leather, hemp, or other materials. One end has a ring, generally of metal, by which the loop is made. Lassoing looks easy. The hunter makes a loop of 5 to 8 feet, holds it in the throwing hand, whirls it rapidly around the head, and releases it at the animal so it will fall around the head or legs. The method of throwing can be varied and the accuracy with which it can be thrown at a full gallop is surprising. However, the skill required to throw a lasso thus is not easily acquired and the lasso has only a limited range.

Equally or more effective than the lasso is the bolas. They have longer range and the skill required is much easier to attain.

South American bolas are of three types: One ball on one thong; two balls, one on each end of a cord; and three balls attached to cords and the ends attached together. The one and two ball bolas are nowhere near as effective as the three ball bolas.

The cords, of plaited or twisted leather, are from 3 to 10 feet long; the balls, of iron, wood, or stone, and enclosed in leather weigh from 1 to 1½ pounds each.

To throw the bolas the thrower takes one of the balls in his hand and whirls the other two round and round his head; then, taking aim, he releases them. They spin through the air; and, when they strike an object, wind around it, crossing each other, and firmly bind the object. When the balls are stone they have enough force to break a horse's leg.

Balls of wood and as large as a turnip are used in bolas for capturing horses without injury. Balls of iron can be thrown to the furthest distances. The main problem in using bolas on horseback is to be able to ride well enough to whirl them so steadily round and round the head so as to take aim and release them, all the while at full speed. On foot the art of the bolas is easily learned.

Another way to throw the bolas is to grasp the cords where they join and twirl the three balls together. In any event, the effect is a pattern of shot about 8 feet across that will tangle and disable rather than kill. Each cord can be as much as 8 to 10 feet long, making a pattern about 20 feet wide. The range of the bolas is from 30 to 60 yards on foot and 80 to 100 yards on horseback.

Eskimos use a lighter bolas for catching flying birds. From 4 to 10 walrus ivory or bone weights are tied to cords of sinew or seal intestines 24 to 30 inches long with a short handle of brass or feathers where the cords join. Carried in a pouch slung from the neck from which they are quickly extracted and thrown, the bolas are said to be effective at ranges of 30 to 60 yards.

The American Indian version was used in the northern areas and was two stones joined by a single cord. One stone was held and the other was twirled round the head. Thrown with a side throw across water at swimming ducks, the stones could skip across the water for amazing distances and were quite successful in snaring or stunning ducks before they could be alarmed and fly.

SURVIVAL TOOLS - #5

T. Fitzgerald

Often thought of only as a child's toy, a pea-shooter is in fact a miniature of a very deadly and useful instrument. Other weapons call for manual dexterity or strength. The blowpipe or blowgun calls on the power of a man's lungs; the air blown out forcefully thru the blowgun propells the projectile with great force.

Often thought to be merely an invention of primitive South American Indians, blowguns were actually much more widespread in their use. Illustrations in many European manuscripts from the Middle Ages show blowguns being used for hunting rabbits, birds, and other small game. Because of the large variety of other projectile weapons blowguns were not in great demand. Nevertheless their production and use did not die out. During the middle 1800s England had a passion for making walking canes with one or even more uses above that of a simple cane. Included in these dual-purpose canes were some hollowed out for use as blowguns. Advertisements listed tubes, darts, pellets, pellet moulds, targets; touted their use for rooks (crows), pigeons, rabbits, vermin, etc., at ranges of up to 50 yards, and acclaimed them as a pleasing source of indoor amusement. They further bade the purchaser to beware of imitations.

By use of a self-made blowgun, an American reported kills on hares as far as 60 yards during World War II.

The blowgun's use outside of Europe is mainly confined to two regions. One is in Asia from Ceylon around to Borneo and New Guinea reaching to Japan. The other is Guiana, Brazil, and Ecuador in South America, also appearing in Mexico and the south-east USA.

Native blowguns are of three types: 1) bored from one piece of wood or bamboo, 2) two long pieces of wood, each flat on one side, are grooved on the flat side and joined to form a tube, and 3) two hollow reeds or canes, one inside of the other. This last type uses very light weight reeds and two are used for sufficient strength. A wooden mouth piece is normally used on all of these. In Borneo a heavy wood blowgun is made from 6 to 8 feet long (type 1) and a blade tied to the muzzle so it can also be used as a spear.

Length of blowguns varies from about 4 to 5 feet to an extreme of over 11 feet. This longer one is used by Guiana Indians. Made from a very thin reed inserted into a length of palm, it only weighs about 1½ pounds.

Bores of blowguns seem to be fairly standard at about ½ inch.

Projectiles are either clay pellets or darts. Pellets require much effort to produce enough force to stun a bird and about 40 feet seems to be their useful range. Darts are much more useful. Borneo headhunters use darts 6 to 9 inches long and 1/16 to 1/8 inch in diameter with a pith cone fastened to the base. These are extremely light and so relatively harmless in themselves. However, they are coated with poison. Six out of ten darts can be put into a potato at 50 paces. Properly prepared and weighted, the headhunters insist they could kill a rhino.

In the Malay Peninsula a heavier dart is used, with an iron point and twisted, cone shaped piece of bark at the base, plus poison.

The Japanese used a sliver of bamboo with paper feathers, also poison.

South American Indians use leaf stems of palm about 9 inches long, with or without poison, padded with cotton at the base.

South India users shot a miniature harpoon. A barbed head fit loosely on the shaft and the two were connected by a piece of string wound around the dart.

American Indians had their version also and used milkweed fluff tied on the base of a wooden dart.

The blowgun is primarily for use within a distance of 50 to 60 yards at birds and small animals. With poison it is also capable of being used against about anything you can think of, including man. Careful preparation, and care that the flight of the dart will not be disturbed by a puff of wind or breeze, allows nearly a 150 yard range.

Modern, machine made, blowguns are available for under $10 from various firms, come complete with darts, and extra darts are available for a small cost. Or, make your own.

SURVIVAL TOOLS #6

By T. Fitzgerald

Bows

The world record distance for an arrow from a handheld bow was recently set at 1077 yards using a modern recurve bow and a special short arrow. Hunting arrow distance records are at 500 yards.

Bows have been in existance since

Paleolithic times (from 750,000 years ago). Actual bows dating from Neolithic times (from 10,000 B.C.) have been recovered in Switzerland. Made entirely of yew wood and 5 to 7 feet long, they are of the type of bow termed a self-bow.

1. Shorter bows from Neolithic times averaging 40 inches long have been found in Asiatic Russia. Some were of wood reinforced on the belly with strips of antler or horn, others were apparently laced with sinew to prevent the wood breaking. These were the earliest forms of composite bows.

After a strong glue was perfected, the three materials, wood, horn and sinew, were joined into one strong piece, shaped and fitted with two notches for the bowstring. A bark or skin cover often kept it from getting damp or excessively hot.

To increase the strength, the ends of the bows were made to curve away from the holder when the string was loosened or removed.

2. In Egypt in 3500 B.C. both one-piece and composite bows were being used. Later, several Egyptian kings boasted of killing elephants, wild bulls, and lions, using bows.

Bows were made of various materials. Some woods used were yew, bamboo, mulberry, birch, beech, sumac, cherry, spindlewood, elm, and whatever was at hand. Also used in various combinations were oxhorn, sinews of various animals, various types of glues, silk, leather, various metals, ivory, birch bark, water buffalo horn, bone, etc. Almost every combination of these seems to have been tried at various times.

3. Possibly the ultimate bow was the Turkish composite bow. Short, about 3 feet 9 inches, unstrung, and three feet two inches when strung, this bow is extremely strong and elastic and requires a pull of about 118 pounds or more.

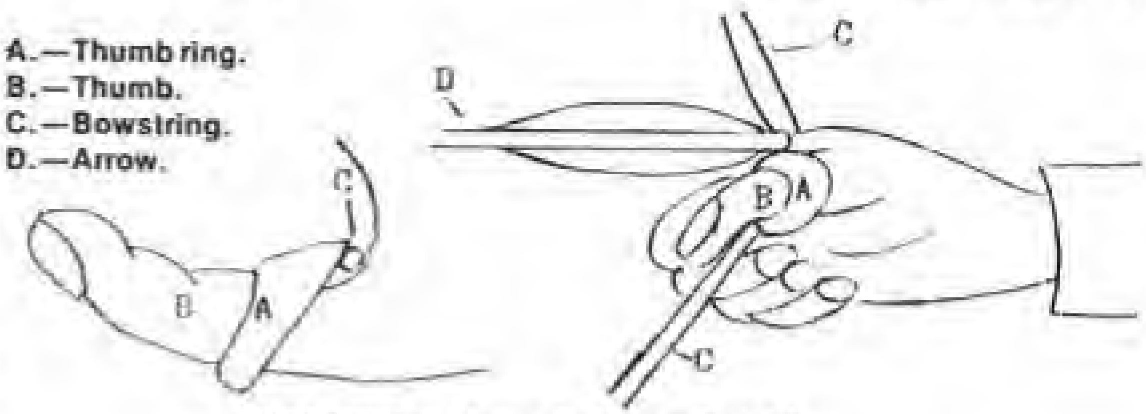
The bow is mostly flexible horn and sinew glued to a very thin piece of wood–1/8 to 1/4 inches thick except for the handle, and from 1/2 to 1 inch wide. The wood offers no strength and is only the core on which the other parts are glued. Because of its length and thinness, the wood is fashioned in three parts; the limbs and handles, which were fitted together, and glued.

4. The inside of the bow is lined with two pieces of horn about 1/4 inch thick and are butted together.

The outside or back of the bow is formed by a strip of ox or stag sinew about 1/4 inches thick.

Thin bark, leather, or skin, is then glued over the sinew to keep it from damage or damp. The horn is not covered. In the better bows the outer covering is then painted red and decorated, dated, and signed by the maker.

A.—Thumb ring.
B.—Thumb.
C.—Bowstring.
D.—Arrow.



The fingers can be curled up or straight.

Turkish bow unstrung.

Turkish bow strung.

Bow strings were originally made of sinew, which was easily spoiled by rain or fog. Later, silk bowstrings were introduced. Sometimes wax was used on the silk bowstrings, but it was not considered absolutely necessary.

The arrow length is normally between 25 and 26 inches.

To draw such a powerful bow, one cannot use his fingers. Instead a "thumb ring" is used. This is a ring, of ivory or other hard material, fitted on the thumb, with a "lip" on the side worn inside, which is used to draw the bowstring. It would seem that drawing a bow with such a ring would hurt the thumb but it is simply not so. You can bend a strong bow further and easier with such a device and the range of the arrow is always further when using a thumb ring than with the conventional finger pull. The bowstring release with the "lip" of the ring is quick and clean.

The best distance achieved by a Turkish bow is over 800 yards, using flight arrows. The range with a war arrow is in excess of 400 yards, using a strong bow and a strong archer.

Compare this with the famous English long bow, a self bow of yew. The maximum range with a flight arrow is 340 yards, and the range with a war arrow is about 200 yards.

Bows have of course been used in virtually every area of the world, for hunting, offense, and defense, but none was so effective as the Turkish bow.

Arrowheads come in a wide variety of shapes, sizes, and materials, beginning with a sharpened stick, then fire hardening the stick, pointed antler, bone, stone, and finally metal.

Against birds and small game a large blunt head is often used. Against just birds, a double-pointed, broad headed, point is used to inflict a large wound and rapid bleeding if a killing blow is not dealt immediately. And, when the target is fellow man, an even greater variety of designs is used.

Bows have even been developed to shoot stones instead of arrows. These have only limited powers though, and are only good for small game and birds at relatively close ranges.

Bows are constructed as simply or as complicated as desired. New on the market are two completely different bows, using to entirely new principles. One has two limbs and a number of pullies. It is more powerful than a conventional bow and easier to draw. The other type has a series of pullies, ONE limb, and a large moveable arc fixed to the other end. More conventional bows are available as one piece or takedown models. Arrows are available in various woods, aluminum, and fiberglass, with an assortment of fixed or interchangeable heads.

The disadvantage of the bow is the extended time and practice needed to become truly expert with one. Advantages such as ease of manufacture of bow and the arrows to go with it, silence, and effectiveness, make it well worth the effort.

SURVIVAL TOOLS #7

By SFC Theodore Fitzgerald

Before we proceed further, it is important to recognize yet another survival tool developed by ancient man, but still used today. The "tool" was the domestication or taming of wild animals and of course the products of the original taming are still with us and used every day.

Dogs are the most important animal to be considered here. Their use in survival atmosphere will spell the difference between life and death to many, many, people.

Dogs were originally used for hunting, burglar alarms, and at times for food when times were rough. All of these applications are still current. A dog will be a most vital part of almost any survival effort, especially if things get as dangerous as is likely in a state of complete collapse. A dog will be almost worth your life as a danger alarm when strangers get near. You will need to train your dog not to bark, however, merely to give the alarm. A barking dog could bring a gang upon you. And, if you have a surplus of dogs, you may have to use them as a food source at the onset of collapse. You may be able to reach no other source of food for hours or even days. Any way you look at it a dog can save your life.

I do not believe that dogs will be of immediate value as hunters after the collapse. For a considerable length of time after the collapse you will not want to do anything to draw unwanted attention to yourself, and hunting would do just that. You would be a walking invitation for an ambush and your dog would probably be too interested in hunting to alert you.

Dogs are also useful for transportation of goods. In the winter they can pull a sled. Winter or summer they can carry a light pack. If you are moving around much this will be a great fatigue saver for you and will not hamper the dog, unless the pack is too heavy or improperly fastened. Don't pack your spare ammunition or first aid kit on the dog though, keep such valuables in your own pack.

Horses will probably gain their major importance sometime after collapse. I do not foresee an immediate demand for horses, burros, etc. Later, of course, they will be of almost priceless value as draft animals for plowing, pulling wagons, etc. Their immediate value will be as food animals. Very few people will need much transportation after the first few critical days, but they will need food. The same reasoning holds for cattle; their immediate value will be as food.

This is not to say that you should slaughter any cows and horses you see because of their food value. On the contrary, if you are not immediately in danger of starving, you should make every effort to keep any cattle or horses in good condition. They will be invaluable aids for long term survival, which is what it is all about. You should also keep any goats you can because they are too quick to go completely wild and are correspondingly almost impossible to recapture later. They are also much easier to keep than cows and give good milk too.

Cats are a bit harder to classify. In ancient Egypt they were trained and guarded the granaries, much as dogs are trained and used. An added benefit was the mice and rats they caught, thus doubly protecting the grain. I do not know how one could train a "guard cat" but they are still valuable as mice and rat catchers. Here, once again, the immediate value will probably be as food.

Guinea hens are good to eat, lay eggs, and will give a loud alarm if strangers approach. Here too, though, they may call attention to your presence that you may not welcome. For an established survival group, capable of fighting off a sizeable group of marauders, they should be of sufficient value to offset this drawback.

Specimens such as cormorants for fishing, hawks for catching birds, etc., are not considered to be of survival value. They are toys for an advanced or secure culture.

Exotic species, such as elephants, will not be considered either.

Pigs are of great value in long term survival. Besides their obvious advantage as food, they are quite intelligent and easily trained. In France they are still trained to hunt truffles, an underground fungus esteemed as a food delicacy. In the middle ages they were often trained to be as good a guard as a dog. If you are hard up for transportation, they even grow large enough to ride. Given the space and opportunity, they will use the same area each time for a toilet and given a pool of clean water to lie in they will forego mud and remain quite clean. You may even decide to trade in your dog for one after seeing all of these good points.

I have only considered those birds and animals with definite survival advantages. Chickens for example offer no survival advantage as, undoubtably, wild game birds will greatly increase and become correspondingly easier to obtain. They require much more care than guineas with none of the advantages.

METHANE GAS AS AN ALTERNATE FUEL/ENERGY SOURCE

By T. Fitzgerald

BACKGROUND:

Methane is a renewable fuel/energy source. Manufacture of it is nothing more than speeding up nature's million year manufacturing process. For uncounted eons plants absorbed the sun's energy and, through the process of photosynthesis, stored it in organic carbon-bearing compounds. When the plants died, anaerobic bacteria (those that live out of contact with free oxygen) consumed the decaying vegetable matter, and as part of their metabolic process, combined one atom of carbon with four of hydrogen. The resultant molecule (CH_4) is methane.

Natural gas, as found in underground reservoirs, or as it come bubbling out of marshes in the form of swamp gas—the process is still going on today—is mainly methane, but also contains 5 to 16 percent ethane (C_2H_6) and sometimes as much as 8 percent hydrogen.

Natural gas is important because there is a lot of potential heat energy stored in those molecules of carbon and hydrogen. Burn a cubic foot of it and you will get somewhere between 1000 and 1100 BTUs (British Thermal Units—a means of measuring energy). Methane gas produces about 678 BTUs per cubic foot.

Methane gas can be used effectively in the place of natural gas or propane by simply drilling the orifices (gas openings) of the stove, lantern, etc., being used, slightly larger as methane is not as "hot" a fuel as natural gas or propane. Caution must be used, just as when using natural gas or propane, as methane gas is explosive when mixed with oxygen in as small a ratio as 14 to 1.

INTERNAL CHEMISTRY OF METHANE GAS PRODUCTION:

1. Anaerobic digestion of waste material will occur at temperatures from 32 to 156 F. The action decreases below 60 and production is most rapid at 85 to 105 and 120 to 140. A temperature of 90 to 95 is the most nearly ideal for stable methane gas production.

2. The proper pH range for anaerobic fermentation is between 6.8 and 8.0. Acidity higher or lower than this will hamper fermentation. The introduction of too much raw material can cause excess acidity (a too-low pH reading) and the gas-producing bacteria will not be able to digest the acids quickly enough. The addition of a little ammonia can raise the pH value very fast. If the pH grows too high (not enough acid), fermantation will slow until the digestive process forms enough acidic carbon dioxide to restore balance.

3. Although bacteria responsible for the anaerobic process require both carbon and nitrogen in order to live, they consume carbon about 30-35 times faster than they use nitrogen. Other conditions being favorable, then, anaerobic digestion will proceed most rapidly when raw material fed into a methane digester contains a carbon-nitrogen ratio of 30:1. If the ratio is higher, the nitrogen will be exhausted while there is still a supply of carbon left. This causes some bacteria to die, releasing the nitrogen in their cells and—eventually—restoring equilibrium. Digestion proceeds slowly as this occurs. On the other hand, if there is too much nitrogen, fermentation (which will stop when the carbon is exhausted) will be incomplete and the "leftover" nitrogen will not be digested. This lowers the fertilizing value of the slurry.

4. Dry vegetable matter has a carbon content ranging from 5,000 to 8,000 BTU per pound; that of green algae, or pond scum, is as high as 11,600 BTU per pound.

5. The "solution" must be agitated to keep it in solution and to preclude the buildup of a hard crust, thus limiting the production of gas.

6. Methane gas also does not pose a half-life hazard for thousands of years as does atomic energy.

TWO SIMPLE METHANE GAS DIGESTERS:

See illustrations one and two

A THREE STAGE TANK METHANE GAS DIGESTER:

See illustration three.

TWO METHODS OF COLLECTING/STORING METHANE GAS:

See illustrations four and five.

THREE METHODS OF USING METHANE GAS TO GENERATE ELECTRICITY:

See illustrations six, seven, and eight.

"SCRUBBING" METHANE GAS TO REMOVE IMPURITIES:

1. Hydrogen sulfide (H2S) is present in methane gas. It supposedly will "eat" metal in digester tanks and will ruin or impair an engine if it isn't filtered out of the methane before being used as fuel This is only theory and many people with experience with methane gas doubt it is present in quantities large enough to be harmful.

2. Methane gas can be "scrubbed" or "cleaned" in various ways by filtering it through:

a. Iron filings which are supposed to absorb H2S.

b. Limewater to remove carbon dioxide.

c. Calcium chloride to extract water vapor.

d. Wood shavings to extract water vapor.

PRODUCING LIQUID FUEL FROM METHANE GAS:

Methane gas can be compressed and bottled, but it has been agreed by most people who claim knowledge in the field of methane gas production that this is not too practical in most cases.

The most economical and best storage of methane gas would probably be in collection tanks (see illustrations four and five).

Methane gas can be transferred to storage bags or gas bottles carried on a vehicle and used to propel that vehicle, as was done on a limited basis in World War II. This is normally not satisfactory and the best possible uses of methane gas are probably in generating electricity (see illustrations six, seven, and eight), and/or used as a substitute for natural gas in heating and cooking.

Methane gas can be "scrubbed" or "cleaned" to remove harmful (?) impurities.

Once produced, methane gas can be converted to liquid form in several combinations that make acceptable motor fuels, either by themselves, or mixed with gasoline. Only the carburetor must be adjusted for handling the different fuel. The formula

$$1\ O_2 + CH_4 + CO + H_2O \xrightarrow[\text{PRESSURE}]{\text{CATALYST } \Delta}$$

yields anything from formic acid to benezene. The chemical proportions, catalysts, temperature, etc., must be varied to determine the best product mix.

ILLUSTRATION # 1

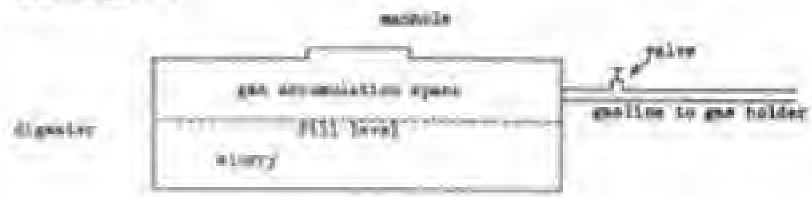


ILLUSTRATION # 2

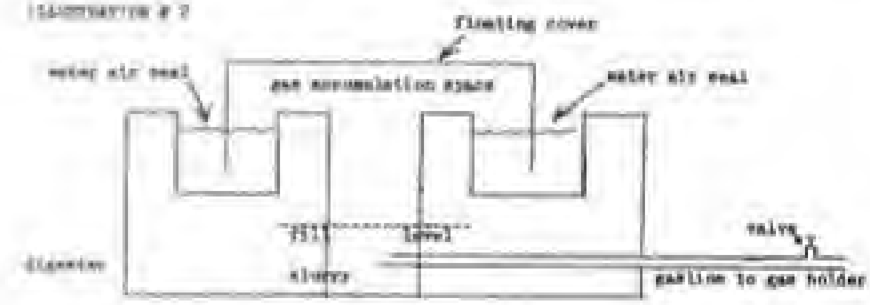
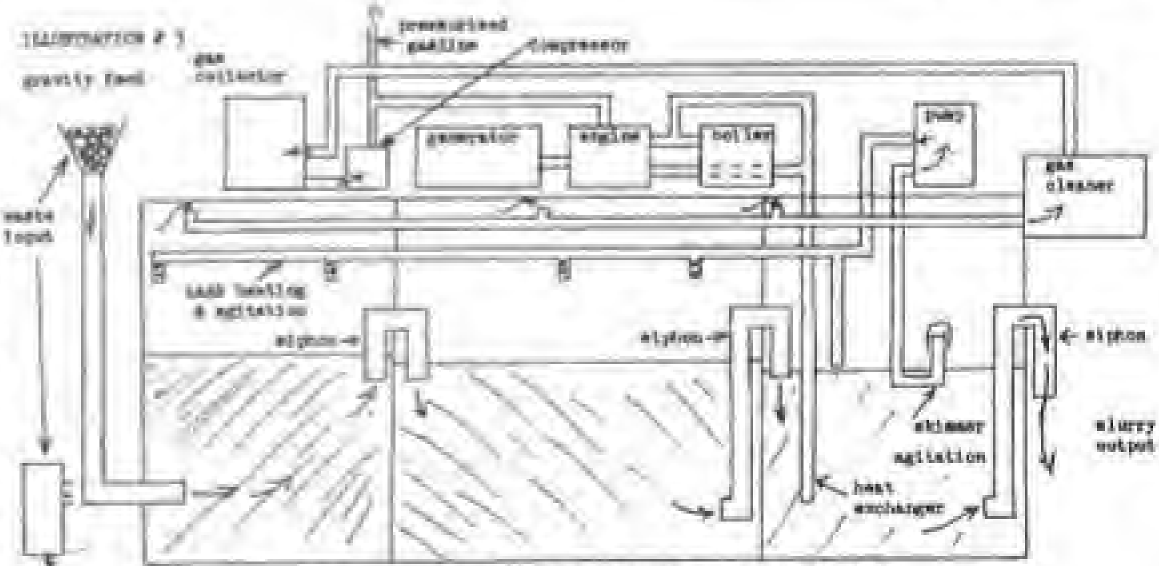
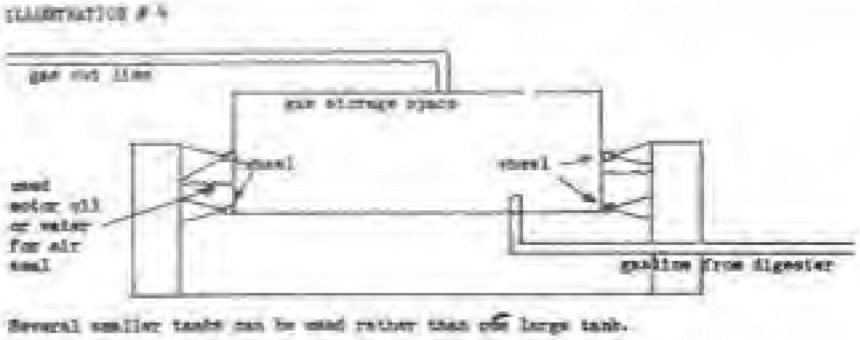


ILLUSTRATION # 3



three stage tank digester unit - not to scale

ILLUSTRATION # 4

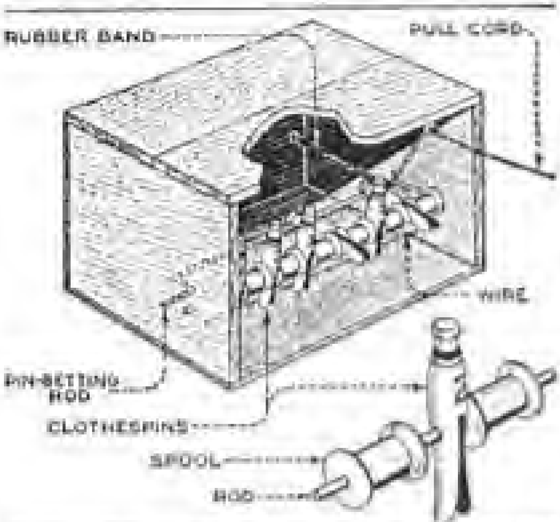


Several smaller tanks can be used rather than one large tank.

Shooting Gallery for Toy Pistols

From Popular Mechanics 1925

Skill in shooting toy pistols, blowguns, and similar harmless weapons that use peas, marbles, or wooden darts for am-

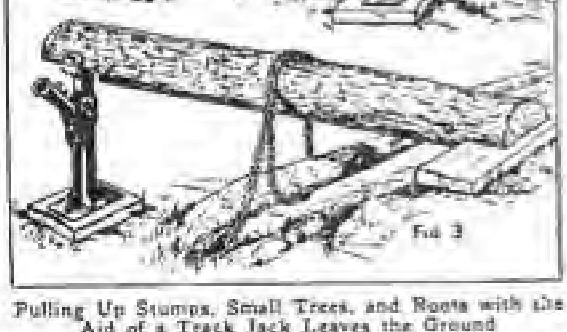


A Pistol Butt for Indoor Use, by Means of Which the Young Marksman can Improve His "Shot," with Harmless Weapons Such as Marbles, Peas, and Darts

munition, can be easily acquired by practicing on a target of the type shown in the drawing. Clothespins, spools, and some wire are about the only materials required. The clothespins, a spool between each pair, are placed on a stiff wire or small rod and fitted in a box, as shown. Back of the clothespins and a little above their lower ends is a second wire that holds them upright; this wire should be placed so that the pins will lean forward a little. When these targets are knocked over by an expert—or lucky—shot, they are caught by the pin-setting rod at the back; this rod is bent from a piece of stiff wire, and is held horizontally by a rubber band. When all the targets have been knocked over, or after each marksman's turn is over, the pins are reset by a pull on the cord tied to the pin-setting rod. If desired, the clothespins can be painted and designated by numbers.

Jack Aids in Clearing Land

From Popular Mechanics 1925



Pulling Up Stumps, Small Trees, and Roots with the Aid of a Track Jack Leaves the Ground Ready for Immediate Plowing

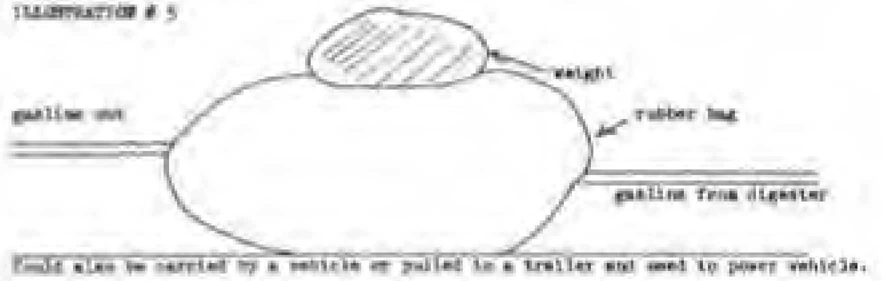
The easiest way to do this is to burn an O2 flame in an atmosphere of methane and collect what condenses. (Run a gasoline engine(perhaps to turn a generator) on a much-too-rich mixture of methane and air, channelling the exhaust into an auto radiator, which is submerged in water or otherwise adequately cooled, and collect the condensed liquid—which should be OK. By adjusting the fuel mix and the length of pipe between the engine and radiator—and, thus the time before quenching of equilibrium reactions—you can get almost any combination of products. Of course, this will involve a bit of experimentation and you will probably not get a useful mixture immediately).

TWO VALUABLE BY PRODUCTS: GARBAGE DISPOSAL AND FERTILIZER:

It is becoming more of a problem daily to dispose of garbage and waste. One mixing of my small lawn produces in excess of 40 pounds of grass clippings. A methane digester uses garbage, paper, leaves, sawdust, grass, manure, etc., as its source for the production of methane gas. When an excess of sawdust, paper, etc., is used, a balance of internal chemistry must be achieved (see INTERNAL CHEMISTRY OF METHANE GAS PRODUCTION above). The digesters shown in illustrations 1 and 2 can be filled up and when the methane cycle is complete be emptied and then refilled for another cycle. The digester shown in illustration 3 is better "fed" less quantities each day as the slurry will move through as the methane is released. Once the material fed into the digester has been processed for its methane gas it is gradually expelled/discharged from the back of the digester (the type shown in illustration 3) as new material is fed into the front. This "waste" or "slurry", both liquid and solid, makes excellent fertilizer, probably better than any commercial fertilizer available today and at no extra cost.

This will not be the answer for all, but for others this may be the answer to self-sufficiency and independence.

ILLUSTRATION # 5



Could also be carried by a vehicle or pulled in a trailer and used to power vehicle.

ILLUSTRATION # 6

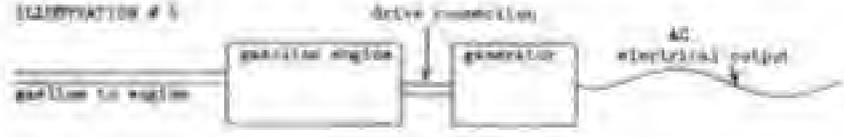
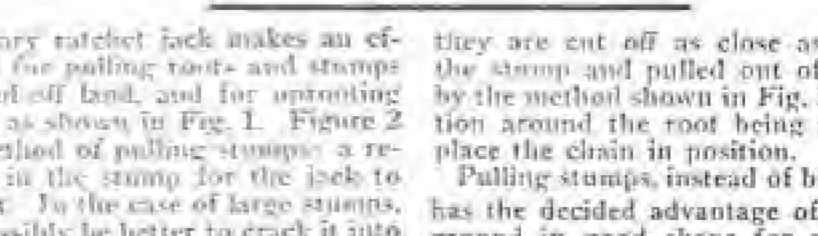


ILLUSTRATION # 7

ILLUSTRATION # 8



If AC power is desired a transformer is necessary, otherwise you will have to use appliances with DC motors.

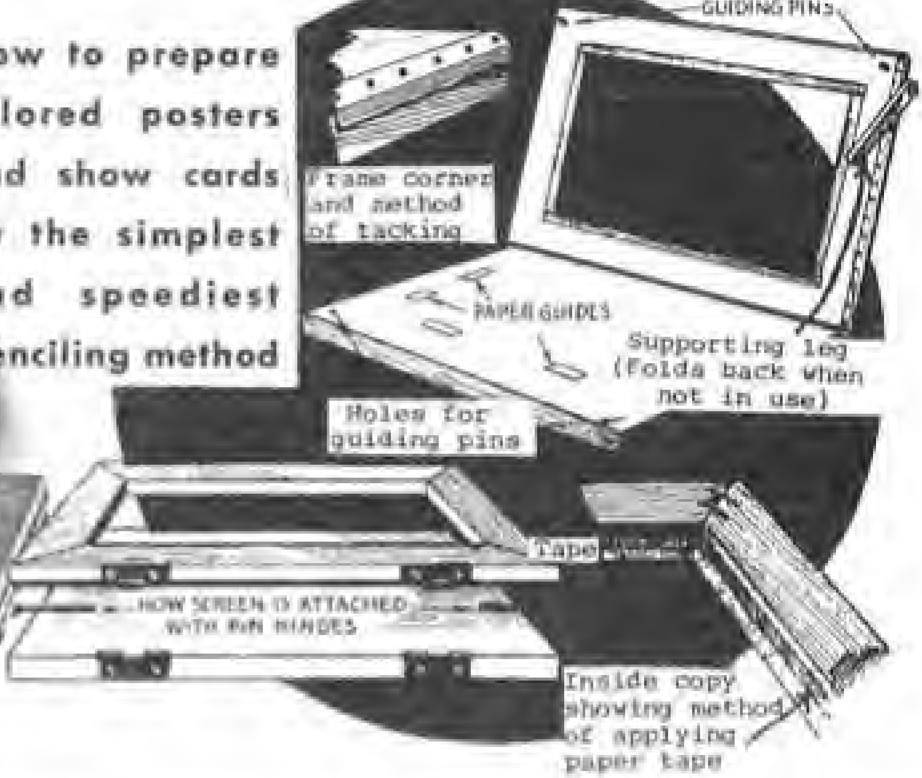
An ordinary ratchet jack makes an effective tool for pulling roots and stumps from cleared-off land, and for uprooting small trees, as shown in Fig. 1. Figure 2 shows a method of pulling stumps; a recess is cut in the stump for the jack to bear against. In the case of large stumps, it would possibly be better to crack it into several pieces with stumping powder and extract the pieces in the same manner. For removing the main roots of a tree, they are cut off as close as possible to the stump and pulled out of the ground by the method shown in Fig. 3, an excavation around the root being necessary to place the chain in position.

Pulling stumps, instead of burning them, has the decided advantage of leaving the ground in good shape for plowing, the humus is not burned out, and if the soil is clayey, it will not be burned hard as brick.

Silk-Screen Printing

How to prepare colored posters and show cards by the simplest and speediest stenciling method

The thick mass of paint is drawn across the back of the screen with a squeegee. A single well-regulated stroke is sufficient



DO YOU ever need quantities of attractive posters to advertise an amateur theatrical show, club party, or home workshop exhibition? Would you like to know a way to earn extra money printing show cards and posters? Then you should get acquainted with the silk-screen process. It is, in essence, a process in which thick paint is forced, by means of a squeegee, through a stencil attached to a tightly stretched screen of silk or other suitable material. It is simpler and more rapid than ordinary stencil printing and leaves no troublesome connecting links to be touched out.

By repeated printings, through properly cut and registered stencils, any number of colors may be applied. The method may also be extended to print on wood, metal, celluloid, fabric, glass, and other materials.

The essentials are a wooden frame, a baseboard or wooden table top, material for a screen, loose-pin hinges, tacks, gum-paper tape, artificial shellac, a squeegee, and the necessary paint and paper or poster board.

For making a small frame, 1 by 2-in. furring strip is excellent; 2 by 2's would be better for a larger frame. The inside dimensions of the frame should be large enough to allow a margin of about 4 in. at each end and 2 in. at each side beyond the largest poster you intend to print. Plane a ¼-in. bevel around the outer edge of one of its sides.

The baseboard may be made from an old drawing or bread board, or the frame may be hinged directly to a wooden table top. Loose-pin hinges are used so the frame may be detached instantly for inspection or cleaning.

For screens, professionals generally use stencil silk or silk bolting cloth. The former costs about $3 a yard, the latter from $6 to $10. Both may be bought from any large dealer in art supplies. For the limited requirements of the amateur, however, ordinary white organdie, costing only 40 or 50 cents a yard, may be used.

Whatever the material, it must be stretched as tightly as possible over the frame and tacked along the bevel. Turn the frame over and seal the inside juncture of frame and cloth with cellulose tape or adhesive paper tape. Apply a strip of tape over this, on the outside.

With the frame hinged to the baseboard and closed down, drive a nail through each of the sidepieces of the frame right into the baseboard about ¾ in. deep. Pry the frame from the base, clip off the sharp points of the nails, and enlarge the holes in the base a trifle. These nails and holes will insure accurate register.

To support the frame between printings, make a leg of wood, 6 or 8 in. long, and attach it with a single screw to the right of the frame, as shown.

The simplest way to make a stencil is to paint it directly on the screen with lacquer, shellac, or enamel. This method, however, leaves a slightly ragged edge. Other methods involve loose paper stencils, photography, and patented transfer films. The following is a proved method, easily carried out, that produces clean-cut results:

First draw your lettering and design in detail on a piece of cardboard or poster board the exact size of the poster-to-be. If it is to be of more than one color, the design may be painted in the desired colors, or colors may be merely indicated with a dash of crayon.

Fasten a sheet of tracing paper smoothly over the finished design with a thin coating of rubber cement. Allow the rubber cement to become partly dry before attaching the tracing paper. Now give the upper side of the tracing paper a coat of artificial shellac. This comes under various trade names and is recommended for screen work because it may be washed out more easily than real shellac.

Next, choose the first color you wish to print and carefully cut through the outlines of all the parts of the design of board, the same thickness as your poster, are glued to the base as shown to act as guides.

Without disturbing the original, the frame is closed upon it, several thicknesses of newspaper are laid on the inside of the screen, and the screen is pressed into contact with the stencil that color. Use a sharp knife and barely cut through the tracing paper. The

The mounted tracing paper is cut with a sharp knife

parts of the stencil that are to be open should then be peeled from the cardboard.

Now take your original, with the stencil on it, and center it on the baseboard. Four little rectangles of card- with a warm flatiron. If properly done, the stencil becomes firmly attached to the underside of the screen, and the cardboard original may be peeled from it. Any mishaps to the stencil may be patched with bits of tracing paper and shellac. Fill the space between the stencil and the frame with a coat of shellac.

First, paper tape is applied to edges, inside and outside. Second, centering the drawing and stencil. Third, heating screen to make stencil stick. Fourth, shellacking margin.

The essentials for a good paint are that it be thick enough not to run, yet thin enough to go through the screen without clogging; it must have body, and it must not dry too quickly. Beautiful oil colors, prepared especially for silk-screen work, may be bought in large paint stores. In a pinch, ordinary flat oil paint may be used. First allow it to stand twelve hours or more, skim off the oil that floats on top, and add a little litho varnish. For silk-screen use, paint must be as thick as apple sauce.

Good water-color paints may be made by adding dyes or show-card colors to a base of molasses or corn syrup mixed with thick starch paste, with a little glycerin added to prevent too rapid drying. Proper consistency must be determined by experiment.

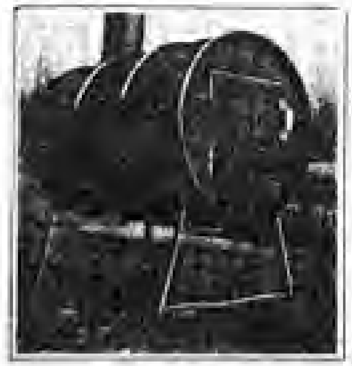
To print, dump a quantity of paint into one end of the frame, raise the frame, place a poster sheet against the guides, and lower the frame again. Then place your squeegee blade behind the mound of paint and draw it with an even stroke across the back of the screen. An ordinary window squeegee will serve the purpose, although special squeegees are made for screening. By varying the angle of the blade in relation to the screen, the amount of paint forced through may be controlled. For the next poster, the squeegee is drawn back the other way, and so on.

After the entire run is made with the first color, the remaining paint should be washed out and the stencil removed with alcohol. The stencils for the second and succeeding colors are made and mounted exactly as the first stencil.

Next page

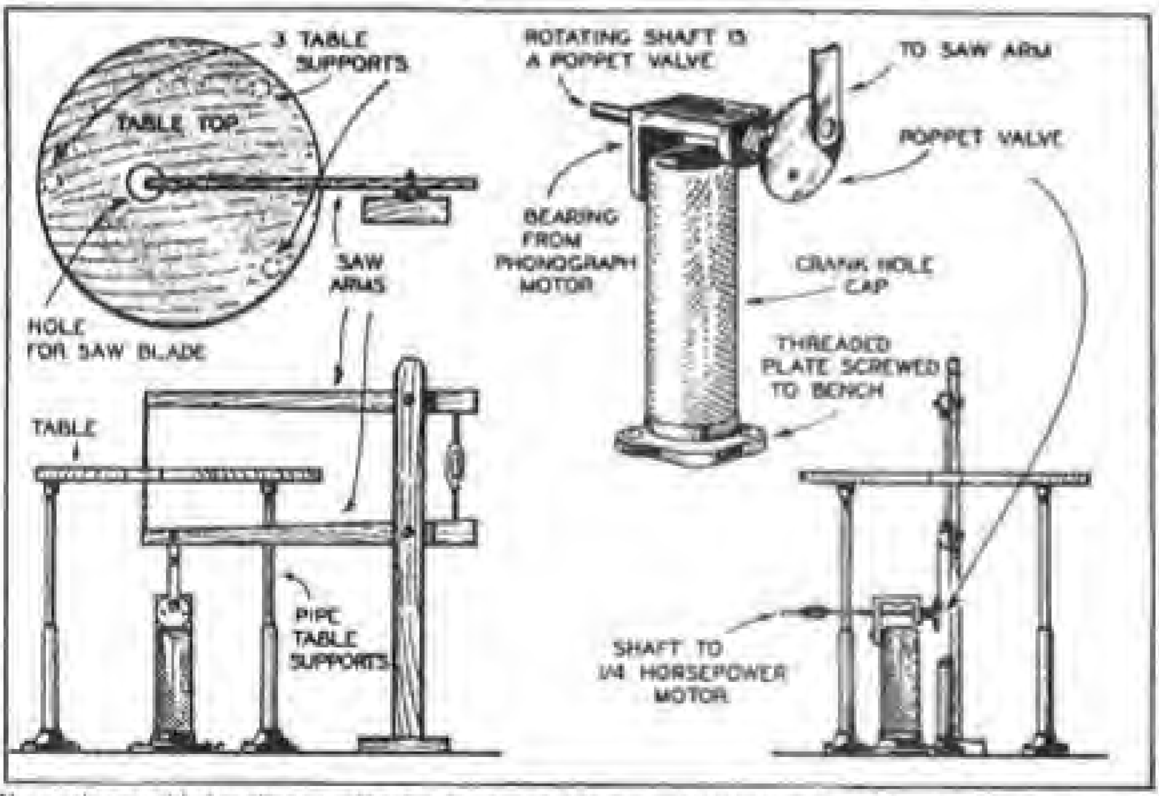
Tracing paper is attached smoothly to the original design with rubber cement; then artificial shellac is applied to the tracing paper.

Keep Warm With Stove Made From Oil Drum



A SURPRISINGLY practical and sturdy stove can be made from an ordinary oil or alcohol drum, as illustrated in the accompanying drawing. The legs may be made from heavy strap iron, which is bolted onto drum. To make the door, simply cut out a section about 14x14, attach a pair of hinges to one edge, reinforce it with tin, then bolt back in the position shown. In the top cut a 6-inch hole and solder around it a piece of tin to take the chimney pipe. An old bike bell makes the draft on the door.

Efficient Jig Saw from Scrap Parts



Jig saw is assembled as illustrated in drawings. Note ingenious arrangement of cam to operate saw arm.

From Modern Mechanics 1931

YOU can turn out some neat scroll work on this simple little jig saw, which is made from a few scrap pieces that every workbench fan usually has around. The arrangement of the saw arms is extremely simple, and are assembled as illustrated above. Mounted on the wooden upright, they should be greased at the pivot points so that they will swing easily. The saw table consists of a wood disc, which is supported by three pipes with flanges, as shown. The blade passes through a one-inch hole bored in the position shown.

The novelty of this saw lies in the device which transmits power to the saw arm. To an upright made from a crank hole cap is attached, as illustrated above, a bearing from a phonograph motor. The shaft and cam are made from an old poppet valve, the connection to the saw arm being made by a piece of strap iron. The motor for operating the jig saw may be connected to the shaft by gears, belt, or joined directly. A quarter horse motor will run the saw without a hitch, but a one-eighth horse will do in a pinch. In operation always keep all parts well oiled to insure smooth running. Attachment of the saw blade is simple; merely bore holes in the ends and bolt the blade to the ends of the saw arms, keeping the joint well greased to prevent heating. The drawings above illustrate arrangement of parts.-

How to Keep Flies Out of the House

From Popular Mechanics 1928

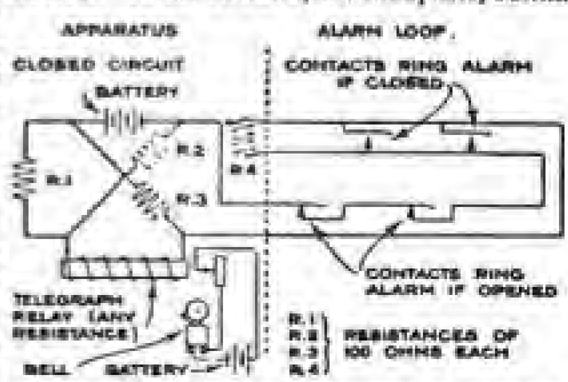
There are fly swatters, fly papers and various kinds of poisons for getting rid of house flies, but all of these have some disadvantages. A better and more effective way is to take a small clean sponge and place it in a dish after dipping in very hot water. Immediately after dipping the sponge, apply a few drops of oil of lavender on it. Flies do not like the odor, and will leave any place where it is present. If the sponge is moistened about twice a day, flies will not come around.

Burglar-Alarm Circuit

From Popular Mechanics 1925

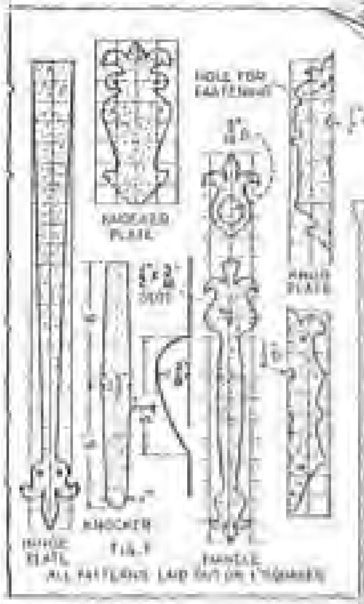
The burglar-alarm circuit shown in the drawing cannot be put out of order without giving an alarm. The only special apparatus required are a relay, which may be of most any type, four coils of equal resistance, and the closed-circuit battery.

With the alarm circuit completely connected as shown, the relay will remain inoperative because both sides of the battery, positive and negative, are connected to each end of the relay winding through equal amounts of resistance. The relay is in a neutral position with respect to the battery and receives no current. Now, should the side of the bridge forming the alarm loop become unbalanced, short-circuited, or broken, the current would flow through the relay winding, causing it to operate and ring the bell, or other alarm device.—C. M. Crouch, Minneapolis, Minn.



A Burglar-Alarm Circuit That cannot be Tampered With without Giving an Alarm; Short-Circuited or Broken Wires Cause the Bell to Ring

HAND-WROUGHT HARDWARE



DRESSING up the oak doors with hand-wrought hardware calls for a handle, knocker and hinge plates to correspond.

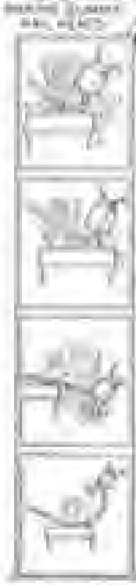
One of the simplest types of hinge plates is pictured in Fig. 1, with accompanying trim to match shown in Figs. 2 and 3. The making of the hinge demands, first of all, a paper pattern ruled off in 1-in. squares on which the design is drawn. The completed pattern is transferred to the stock, which can be either ⅛-in. wrought iron, or ⅛-in. Swedish iron, which is of the same general malleability but of finer texture. Soft steel, which is considerably harder than either of the others but of fine quality and fairly practical for shaping "cold," can also be used. Brass and copper, too, produce beautiful effects. The design is first cut out with a hacksaw and cold chisel, as in Fig 4, and the edges are then smoothed with a file. Holes should be drilled through the hinge at the points indicated to take fastening nails, and as the door itself is not dependent on these fastenings, they may be held in place merely with hand-forged pyramid-headed nails. These can be made quite simply by filing the heads of round-headed galvanized nails to obtain the proper shape, or by making dummy heads from a ⅜-in. square piece of wrought iron, as shown in Fig.

6. The bar is first drilled lengthwise down the center, the end is filed to a pyramid shape and the filed portion then sawed off. The dummy head thus formed is held in place with a small finishing nail, after which the dummy head is lightly peened over the nail head to cover it.

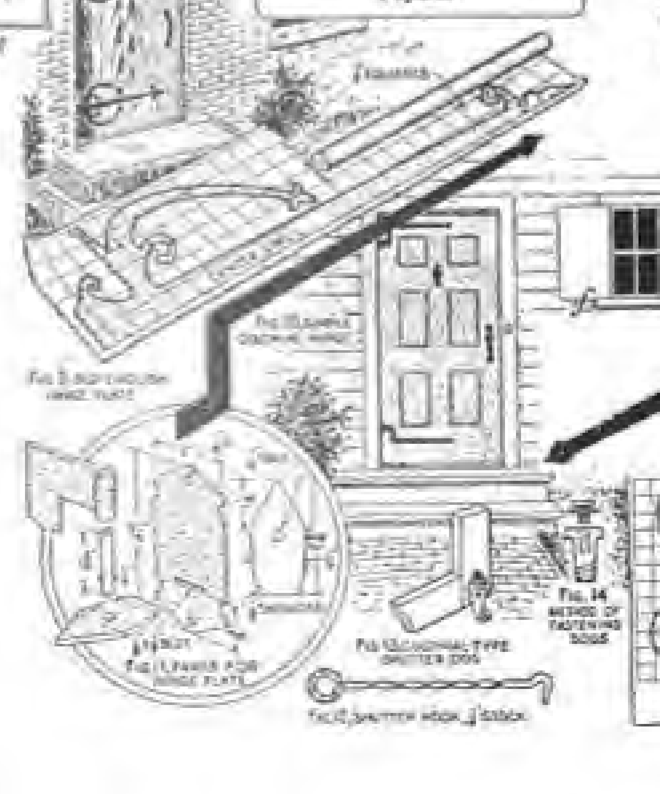
The door knocker to match this set of hinge plates is made from two pieces of ⅛-in. stock and shown in Fig. 3, while its pattern is given in Fig. 1. The bending from eye to curl can be done by working the stock on a flat surface with a hammer, as shown in Fig 7. The eye is hammered first; then, by gradual rolling from the smaller curves into the larger ones, the complete curl of the knocker is fashioned. The piece can then be slipped over a section of pipe and lightly hammered to take out bumps and hollows. Fig. 8 shows the assembly of the two pieces, the knocker portion being held to the plate with a soft-metal rivet, fitting the turned-over portions of the plate. Like the hinge plate, the fastenings are fake nails, but these should be as long as possible in order that they may have greater holding power. Round-headed wood screws may be used throughout, if the heads are hammered down later. A door handle and plate, in a matching tulip design, to fit any standard cylinder lock are also shown. The handle portion of the lock proper is bent to shape and is rounded in the front, while the concave back can then be built up with solder hardened with antimony. If the handle is of the knob type, the knob should also be hammered, as in Fig. 18.

Other designs in door trim are equally feasible. The more ornate old-English hinge with accompanying hardware, as shown in Fig. 9, is particularly adapted to some homes, while the simpler colonial type, shown in Fig. 10, is well suited for either town home or lakeside cottage. Hinge plates for chests, toolboxes, etc., are shown in Fig 5. Plain or hammered brass, copper or aluminum may be used for these smaller items.

From Popular Mechanics 1931



Hand-Wrought Hinge Plates of Various Designs Are Deservedly Popular



Finishing the hardware is often done by applying about three coats of linseed oil, burned off with each successive application, which blackens the metal. This is the best finish for exterior hardware. After the blackening process, the high spots are brightened by rubbing with emery cloth, and spar varnish is applied. Another popular finish is obtained by rubbing the material, if brass or copper, with fine powdered pumicestone, soap and water. This will leave the metal quite bright for a time, but it soon changes to a deep, rich bronze color. If desired, copper can be oxidized by dipping it into a mixture of liver of sulphur and water, brought to the boiling point. The pieces are then rinsed in clean water, after which a fine brush and pumicestone are used to slightly brighten the high spots.

It is quite practical to go a step farther and make actual working hinges, as shown in Figs. 11 and 16, for use on shutters and light doors. Attractive shutter dogs or "hold-backs," to match almost any design, are shown in Figs. 13 and 15. Both of these are cut from flat iron to the dimensions indicated, and are held in place with a ¼-in. bolt, which is tapped into a lagscrew, as shown in Fig. 14. The shutter-dog design in Fig. 13 should be made slightly concave so that the sharper edges will not mar the shutter. Hooks are also quite necessary if a semi-adjustment of the shutters is desired. These are readily fashioned from ¼-in. square stock, as shown in Fig. 12, while the twist can be made by means of a pipe wrench, with the stock inclosed in a ¾-in. pipe to prevent kinking, as shown in Fig. 17. The eye and hook are formed later.

The Horse as a Survival Tool

By Patrick Wastie

For many hundreds of years before the advent of "modern" (and wasteful) transportation such as automobiles, planes, etc., the horse was the major means of transportation other than foot. The Arabs were probably the first to domesticate horses. After the crash, automobiles, etc., won't be much good for awhile since the sources of hydrocarbon fuels will be shut down. That's where the horse comes into the picture. Although not economical for individuals, groups would be wise to latch onto some horses and maintain them. Care is basically simple and comes under four headings: 1). Food, this is probably going to be the single most expense of owing a horse. There is no average quantity of feed for a horse. Every horse is different and needs to be fed accordingly. Some factors influencing feeding are how much work it is doing and how old it is. Of the grains used to feed horses. Oats is the one that is used in the greatest quantities. Second is corn. Both these grains are grown without too much difficulty so your horse need never go hungry if you have a farm. Commercial feed is a mixture of oats, corn, barley, various nutrients, and molasses. This glop is called sweet feed and is pretty sticky on account of the molasses. If you live where the summers are hot, adjust your feed level as the amounts of carbohydrates in sweet feed can cause an animal to get sick in hot weather. Sweet feed is about $5.00 for 50 lbs. or 10 cents a pound.

Hay is also a consideration. Don't buy junk hay. Steer away from hay advertised as "cow hay." This doesn't mean you have to go out and buy $5.00 a bale hay. Just make sure it is not junk. During the cold part of the year feed your horse one or two "flakes" (a bale of hay is about 10 or 12 sections or flakes) twice a day to provide roughage and nutrients normally provided by grass.

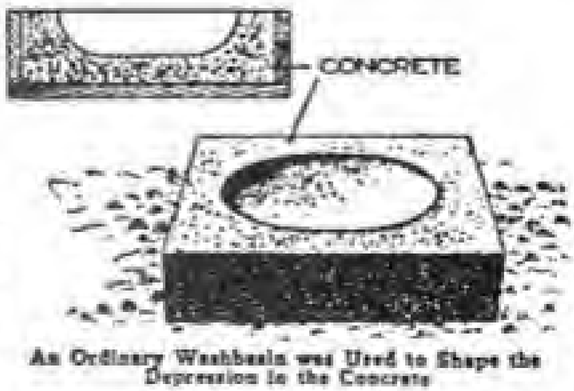
A mineral block is also necessary to provide trace minerals and salt. They weigh fifty pounds for the large size but you can get them in 5-lb. brick sizes. Put your block in a basket or some other form of holder so that it can drain properly. Pasture is usually about 1-2 acres per horse. Remember, if things get hard, horses can make people-feed, if need be. 2). Water is probably the easiest thing to come by (unless you live in California). A horse needs plenty of clean, cool water to maintain itself. A horse has been known to drink 10 gallons of water in a day's time. Keep that in mind. When choosing a watering container, try to allow 8-10 gallons for every horse using that trough. The poor man's trough is simply a used bathtub that is plugged. 3). Shelter is the least necessary item of horse care. Sure, it looks nice to have a barn to put your horses in, but is it really necessary? Most horses prefer to stay outside. In some of the most blinding storms, a horse won't go into a stall door 3 feet away. So, building a barn can be a great waste of money; but the choice is up to you. 4). Health care, is best left to a veterinarian. However, there are a few things that can be done by yourself. Examples are giving injections, taking temperatures, etc. Most health care is routine, such as having hooves trimmed. But in the event of an emergency, don't hesitate to call a veterinarian. Better safe than sorry.

The above is only meant to whet your appetite for an in depth review. Go to your public library and check in the animal care section. They should have some excellent material on horse care. If they don't then they should be able to order it. Good luck!

CONCRETE WATER BASIN FOR POULTRY

From Popular Mech. 1919

A concrete worker was asked by a farmer to build a concrete basin for watering the poultry. Having no forms at hand, the mechanic used an ordinary washbasin and a wood box as shown in the illustration. The basin was greased before it was placed in the concrete. The completed concrete basin was buried with its upper surface level with the ground.



An Ordinary Washbasin was Used to Shape the Depression in the Concrete

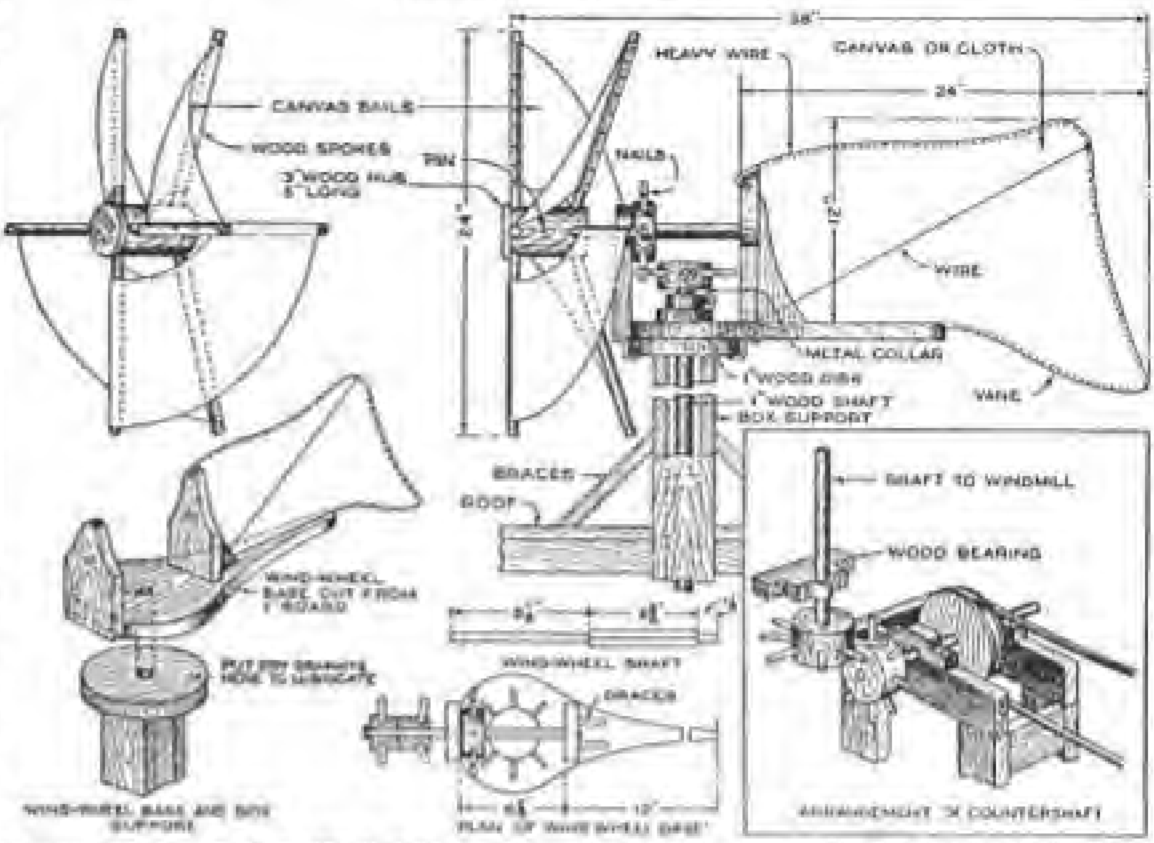
Homemade Soap Washes Clothes without Rubbing

From Popular Mechanics 1931

A soap, which will wash clothes without the usual rubbing, but only rinsing, can be made of common laundry soap cut into thin slices, 2 lb., sal soda, 2 lb., water, 10 qt. Mix the above ingredients and boil for two hours, after which the solution should be strained. Put the clothes into a tub, adding 1 lb. of the soap to every bucket of water. Let the clothes soak in this solution overnight, after which they are thoroughly rinsed.

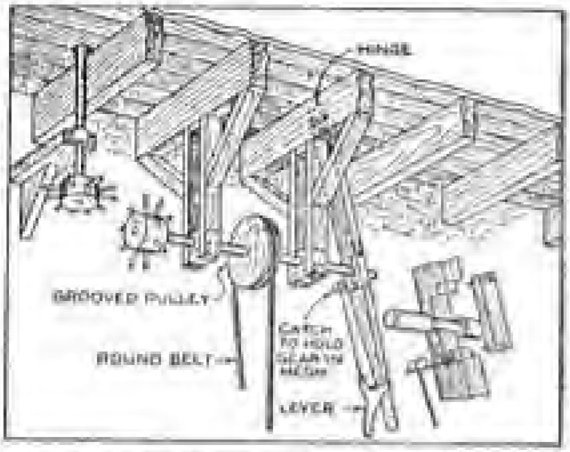
Windmill Power Plant for the Amateur's Workshop

From Popular Mechanics 1925



Constructional Details of the Windmill Power Plant: Such a Plant Is Capable of Operating Light Lathes and Similar Machinery. Besides, It can be Used for Operating Such Things as Churns and Ice-Cream Freezers on the Farm, Where Its Assistance Is Particularly Desirable

COMPARATIVELY few amateur mechanics have their shops equipped with any device for operating light machinery by power, and many others have forgone the pleasure of such machines and tools on account of their lack of power. This article describes and illustrates a windmill that will deliver sufficient power to drive light lathes and similar machines. All parts of the mill are of such simple construction that little or no difficulty should be encountered in its making.



A Simple Gear Shifter for Starting or Stopping the Machinery Driven by the Windmill Power Plant

The wind wheel proper is simplicity itself, consisting of a wooden cylinder into which eight wooden spokes are driven. The canvas sails are attached to the spokes in the manner indicated, and given a coat of varnish. A hole is bored through the wooden cylinder to take the rounded end of the shaft, a pin serving to hold the two together.

One-inch boards are used for the wind-wheel base and its box support, as indicated, the vertical pieces of the base being drilled to accommodate the wind-wheel shaft. A simple gear, having a square hole through its center, is secured to the square end of the shaft; this gear consists of a wooden disk of suitable size in the circumference of which headless nails, evenly spaced, are inserted.

The vane, which holds the wheel to the wind, is made by sewing canvas over a stiff-wire frame, and varnishing the same as the canvas sails. The wind-wheel base rests and revolves on a wooden disk nailed to the top of the box support, plenty of dry graphite being used between the two surfaces to lubricate them.

The vertical shaft has mounted at its upper end a gear similar to that on the wind-wheel shaft, with which it meshes, as indicated in the drawing. A metal collar and setscrew serve to keep the two gears in mesh. The power of the windmill is transmitted to the machinery, underneath, by another set of gears in the manner shown in the insert.

For starting and stopping the machinery, a simple gear shifter is provided, as shown in the smaller drawing. A wide groove is cut in the shaft over which the gear-shifting lever is fitted, as indicated. To hold the gears in mesh while the machinery is in operation, a catch which engages the bottom of the shaft hanger is made, simple means being provided for releasing the catch so that the gear shifter can be moved.

Of course, the operation of such a power plant is dependent entirely on the wind, but if there is any wind blowing, no matter from what direction, the windmill will operate. Such an apparatus can be arranged to drive such small machinery as churns and ice-cream freezers, and the speed can be regulated by varying the size of the driving and driven pulleys. The gears, however, for ease in construction, should all be of the same size.

IS YOUR DOG FIT TO JOIN YOUR SURVIVAL GROUP

by Ron Lank

I would like to emphasize that the lifestyle I am writing about will be only a temporary expedient. It will exist only while those people who were unprepared are in a state of panic and dying for stupid reasons, even though potential food and other means to save themselves are at hand. Soon you will have to go ahead and begin the steps to rebuild, because only by doing so you ensure your long term survival.

It is difficult for anyone to look at his or her own dog objectively, someone else's dog perhaps, but not that one special dog. You will be in no position to own a pet. Your dog will have to be cold bloodedly considered for what value he or she may be to you as a fellow Survivalist.

The job which your dog would be given would be the one it knows instinctively, sentry duty. With Fido, the night shift sentry patrolling it would be very difficult for anyone to murder you in your sleep.

On the other hand your dog has to eat. Also it would be impossible to stay inconspicuous as you must if some idiotic mutt keeps yapping at songbirds. When it comes time for you to go hunting, most extreme co-operation would be required from your dog for it to remain quiet while you stalk your supper.

The show dogs as a group can be by-passed for survival use. They are bred for looks, not brains.

The sporting breeds offer possibilities, provided that the dog that interests you has been bred for the field, not show. Even then it would be best to avoid the very finest of these. You want an adaptable dog, not a specialist. At least the hunting breeds have one vital ingredient, brains.

The breeds of dogs which have been deliberately bred to be house pets also offer possibilities. They are small, and usually alert and intelligent. Avoid any dog with a stiff price tag, because as the price goes up you approach the brainless show dog strains. Many of these dogs are high-strung; avoid them. Among these small pet types you will find many individuals, each with the potential to become an alert sentry that doesn't eat much and has brains enough to keep quiet.

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Don't deliberately pass up any dog of any breed because of its small size. A cold wet nose in your ear followed by a whining snarl will have you instantly wide awake with your fists clenched around your rifle, should the need ever arise.

For general defense size would mean nothing. Even a well trained team of killer dogs is apt to see their expensive training wasted by a carefully placed fusilade of your bullets cracking over their heads and thudding into their targets.

The German Shepherd has some excellent strains, but like any of the larger breeds, it eats. The lower priced strains tend to be vicious and stupid. If you can stash away a considerable quantity of dog food, get one from a reputable breeder. Tell him you want the dog as a house pet that could provide home protection. That way you'll get a sentry with the two vital ingredients that a survival dog must have, brains and common sense.

I don't blame you if instead of visiting a kennel to pick up that perfect Survivalist, you try to make do with your present dog. Your dog may be just a spoiled mutt at the present time, but when your behavior reveals the extreme gravity of the situation, your dog will either watch you very closely for leadership, or die of heartbreak because his good old days are over.

Your dog will have to learn to respond to hand signals. The two most important of these are the finger over your mouth meaning "quiet," with the other hand clamped around the dog's muzzle at first for emphasis. The other is the finger speared straight down at the ground, meaning "sit."

A disobedient dog could end things for all of you with one blunder at the wrong time. It is only natural for any dog to test you occasionally, just to see what it can get away with. Such behavior must be countered by the most extreme reprisal at the earliest possible moment, preferably from the heavy belt around your waist. I realize that delivering such a beating would sicken you with its brutality. But I hardly think that death coming to you and your group in the form of starvation or a gang of looters would be any less brutal! A bit of leniency is not really leniency if it results in a few dead Survivalists.

Such strong-armed leadership will help your dog to understand the seriousness of the situation. It will show your dog that you are sincere when you give him an order and will show that you are a powerful leader, well worth following, because you are capable of overcoming the problems that lie ahead. Such leadership will give your dog a feeling of security. Your dog will very quickly smarten up and make sure that you don't exercise such strong armed leadership too often, at least not on his backside.

There is a chance that your friends are apt to mutiny against your strong-armed treatment of your dog. There is another way to teach discipline to your dog. However, it would be best to have your dog already familiar with it when the time comes. It is known as parade squaring the dog.

After your dog's next act of disobedience tie a fifty foot or longer rope to your dog's collar, at one end of the discipline area. Order the dog to "sit." If your dog refuses, give your dog a swat with an empty glove, not hard enough to get people hysterical, just hard enough to impress your dog.

March the full length of the rope, uncoiling it as you go. If your dog starts to follow you, give the dog a swat, return the dog to position and repeat the "sit" order.

March the full length of the rope, without your dog. Turn around and call the dog. If your dog refuses or doesn't come fast enough, help the dog by reeling him in hand over hand. Tell your dog to "sit." March to the far end of the discipline area with your end of the rope in your hand. Call the dog. Reel the dog in if you have to. Tell the dog to "sit." Start marching another lap, and repeat and repeat and repeat.

After the last time you have to swat your dog, do fifty more laps of the discipline area. Untie the rope from your dog and try one last lap without it. If your dog obeys, you are done. Pat your dog and go do something else.

If your dog refuses, brace yourself. Next time you get your hands on that dog the two of you have, hopefully, only fifty one more laps to go.

No one will seriously object to you disciplining your dog this way, because of the small amount of brutality. Your dog will find this method of discipline at least as severe as the strong armed method because of that horribly prolonged monotony. Either way, your dog will get the idea. You order. He obeys!

When the time comes, your dog will have to adapt to some grim new foods when our conventional dog food runs out. He will see that you to have had to adapt to new foods. Switching over to a diet consisting of rabbit guts, and such slop, will be made a lot easier by watching you and your gang share the rest of the rabbit.

Some dogs will stubbornly refuse to accept such traditional dog food. There is no point in throwing the guts away and offering your dog something better, something that a human being could eat. Any dog thrives on such treatment, and yours would be a fool not to take advantage if you can be suckered in. Not all dogs are fit to be Survivalists. Leave the guts alone. Let them wait for your dog. Offer no alternative food. Turn your back on your dog and the guts, and tell the others to do the same. Let your dog decide. To your dog it will be a matter of life or death. Your dog has more right than you to make the final decision.

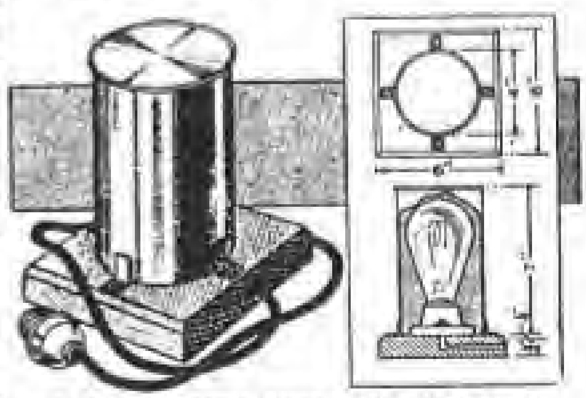
Unless your dog has been hopelessly spoiled, he or she will make the transition more easily than anyone else. The dog that barks at the postman, and later wags his tail and prances around to greet you at the door is already half way there.

A FIFTY CENT ELECTRIC STOVE

From Popular Mech. 1919

Few persons realize what an intense heat may be developed when the globe of an ordinary incandescent lamp is tightly inclosed, largely eliminating the loss of heat. When the lamp is inclosed, the temperature will increase until the rate of radiation is equal to that at which the heat is generated. A good reflector is a poor radiator, hence, when the metal wall surrounding the lamp is bright and shiny, both inside and out, the heat is reflected inward.

To make a small stove that will keep liquids warm, melt paraffin, dissolve glue, etc., procure an ordinary 16-cp. carbon lamp, a porcelain receptacle, and a bright, clean tin can, about 4 in. in diameter and 7 in. long. Thoroughly blacken the bottom on the inside, and then solder on four small brackets, cut from sheet brass or copper, so that the can may be held down firmly, when inverted on the base. The latter should preferably be made of hard wood, with the upper edges beveled, as shown. Next bore the hole for the wire or flexi-



A Handy Electric Stove can be Made at an Outlay of 50 Cents

ble cord. Fasten down the porcelain receptacle, connect the wiring, screw in the globe, and screw down the tin can; the stove is then ready for operation.

Practical Food Storage

By Tommy Murphy

Some foods store a lot better than others, and the temperature at which they are stored is an important factor. Generally, we want to have at least a one (1) year supply of food on hand. One year is adequate as it is enough to see you through the four seasons so that at some point you will be at the proper time for planting vegetables. Cost is always a factor in such planning, so it is best to use the food items that are most easily adapted to everyday use. The ordinary foods available from retail stores are not entirely satisfactory for storage. Since the storage life is not very long, these foods must be replaced on a periodic basis. They are bulky and require considerable storage space. Why consider this type of food in our plans? Well, basically because of the low cost, easy availability, most are ready for consumption with no cooking required, and for the most part, no additional water is required for preparation. These factors have to be weighed against the short term storage life.

Since we are thinking about a one year supply, at first thought, storage life might not seem to be very important. There would be no problem if we could know that the items we wish to stockpile were fresh when they came off the shelf. Since the items have probably been there a short while, and in the warehouse prior to then, it is comforting to know that most of the items that we want to store have a shelf life that is longer than might be supposed.

It is easy to build up a supply of goods that are packaged in the conventional way without a strain on the budget. It is usually quite easy for my better half, for instance, to find, say peaches, on a super special and to buy several cans extra for our stockpile. Then she puts the date of purchase on each can with an indelible marker, and as the shelf life reaches one year, she rotates the goods into the menu and replaces with fresh supplies. This method requires a little record keeping and a little work, but it sure is satisfying to look over the hoard and know that we won't be caught short; it really creates a good feeling of security.

In planning a food reserve, good nutrition is very important. It is expected that in a survival situation, individuals will be under a lot of stress so it is best not to spring any new or unusual food on them. Stick to basic family favorites. Go to the local library and check out books on family nutrition, and have the pertinent charts and tables photocopied. Survival demands a lot from a person, and failure to observe a reasonable balance between fats, proteins, and carbohydrates, in order to insure an adequate supply of vitamins and minerals, can cause health problems.

The storage life of supermarket foods varies. Generally the foods that are least refined are the most stable. Salt and sugar for instance, can be stored for a long periods without deterioration if they are kept dry. Certain dried foods such as beans, peas, and rice also have a long storage life if protected from insects and moisture. At 70 degrees F., it is possible to store unrefined foods and unprocessed cereals and seed foods for periods of time in excess of 10 years if properly packaged. Also such dehydrated items as instant coffee and tea, instant puddings and gelatin, can be stored, again if properly packaged, for 7 to 10 years.

The problem with most canned goods of high moisture content is that they spoil mainly because of corrosion and thus deterioration of the metal can. Even with this disadvantage, cannned goods can be stored at a temperature of 70 degrees F. for a 2 to 4 year period. Containers that are made of glass are better suited for long term storage, but many food items that are available in cans, are not in jars, and of course, breakage could occur.

We have found that buying food for storage is a very good hedge against inflation. Also by buying food in case lots we save even more. So, buy food and save more money in a year's time than you could earn on a savings account in a bank. Not only is it an economical matter to buy now and store but it ensures that you have a reserve for any emergency.

As a rule to follow in the shelf life of foods, remember that temperature plays an important factor. Try to keep items as cool as possible but DO NOT let canned goods freeze. The rate of food deterioration will double for every 15 degrees increase in temperature. For instance, an item stored at 55 degrees, with a 4 year shelf life, will only have a 1 year life if stored at 85 degrees.

When choosing canned goods, reject any cans that have defects, such as rust spots, or dents. You might as well start with cans that are in good condition. When opening a package or can that has been stored for some time, carefully check the contents for edibility. Look for any change in color, odor, in texture, such as caking, curdling, or jelling, mold growth, interior rust, fermentation, etc. If it is the least bit suspect, do not use it. Sometimes a container will appear rusted or whatever on the outside, but the contents will be perfectly safe.

The following list will give you an idea of typical items and shelf life to be expected at 70 degrees F.

Item:	Package type:	Storage Life at 70° F.
Applesauce	glass	2 to 5
Apricots	can	2 to 3
Beef Stew	can	2 to 4
Beans and Franks	can	1 to 4
Beef Goulosh	can	2 to 4
Beef Bouillon	glass	2 to 3
Beverage/Base	glass	2 to 3
Coffee, Instant	glass	2 to 5
Corn Beef Hash	can	2 to 4
Chicken & Dumplings	can	2 to 4
Chicken	can	2 to 8
Corn	can	2 to 3
Jam	glass	2 to 5
Luncheon Meat	can	2 to 3
Lima Beans	can	2 to 3
Milk, non-fat, inst.	can	2 to 5
Peanut Butter	glass	2 to 5
Potatoes, Instant	can	2 to 5
Peas	can	2 to 5
Peaches	can	2 to 3
Pears	can	2 to 3
Raisins	carton	2 to 3
Roast Beef	can	2 to 4
Tuna	can	4 to 8
Condensed Soups	can	1 plus
Vegetable Oils	can	2 plus

Most food storage lists such as those from the Office of Civil Defense, show shorter shelf life than this one, mainly because they consider the conditions under which most people would store canned goods, and thus are typical or average. Now the people who read THE SURVIVOR, are not typical or average. We make sure our stuff gets the very best treatment as does any "tool" of survival.

Dried foods are in the same ballgame but come under different rules. Water is needed for their preparation and cooking is needed, (except some dried fruits can be eaten as is). Dried foods are usually stored in bulk containers, rodent, insect, and rustproof galvanized cans, which can be purchased at most feed and seed stores, or co-op's, etc.

It is desirable to store grains, such as wheat, corn, rye, etc., together with a hand grinder. These items store much better in their original form than in their refined state.

Certainly there is a limit to the amount of food that you can store. The purpose of a food reserve is to get you through rough times and in good shape in order that you may have a chance to provide for your future needs. There is really no secret to being a Survivor, just a common sense awareness of how delicate and vulnerable our nationwide system of food distribution is to any upset, whether manmade or natural, and preparing accordingly. With adequate food reserves as well as associated goods, come what may, you and your family have a good hedge on Survival.

Survive Through Handwriting Analysis

By D.C. Besly

"His handwriting shows him to be treacherous!"

Nineteen hundred years ago, Emperor Nero voiced the above observations concerning a member of his court. It was the first known recorded conclusion regarding man's inner character as reflected by the mark of his hand.

The significance about Nero's statement is the paradox of the kettle calling the pot black. If history is accurate, it is doubtful if Nero's handwriting could have stood up to a searching, in-depth analysis.

Nero reputedly murdered his mother and later his wife. Rumor blamed him for the great fire in Rome, but he accused the Christians. It would be interesting to have graphic evidence of the emperor who recognized treachery in others while obviously holding a lofty opinion of himself. A universal failing that is current to many modern day politicians and others with special interest axes to grind.

The analysis of handwriting allows the analyst to see the inner being as he really is as opposed to what he pretends to be. It strips away the veneer of shame to lay bare the truth of reality. An acquaintance to whom this writer once demonstrated an exercise in analysis later commented, "Next to a twelve-gauge shotgun, that's about the best self-protective device I've seen yet! You can really tell who the phonies are !"

Subsequent articles in the months to come will fully explore violence in youth, dishonesty, integrity, leadership, mood, emotional response, vitality, cunning, hypocrisy and a diverse galaxy of useful genres and accessories too numerous to catalog here. For the moment, some uses and history will be dealt with.

The ancient Chinese recognized the psychology of handwriting. King Jo-Hua, who lived between 1060 and 1110 as a philosopher and painter of the Sung period, observed that "handwriting infallibly shows whether it comes from a vulgar or noble-minded person."

Cardinal Richelieu observed, "If you give me six lines written by the hand of the most honest of men, I will find something in which to hang him!"

In France, every educator must have a working knowledge of graphology, not only to understand themselves better, but also to determine basic conflicts in their students, the better to guide them in addition to determining and developing latent talents and abilities. Additionally, a truck driver is not employed in the same country until his handwriting is given a thorough, in-depth analysis to determine if he is a safe and careful driver, but also to determine honesty, if the job requires the handling of cash and valuable merchandise.

There are twenty-five distinct trait strokes that reveal dishonesty, but only four such strokes need to be present in a specimen of script to disqualify a prospective employee for a position of trust. The signature of a recent late long-time bureau chief of the nation's leading law enforcement agency revealed six strokes indicative of dishonesty. The moral being, one never knows when and where such unexpected evidence will present itself.

On the staff of every school in Argentina is a graphologist whose task it is to keep track of student progress, and to detect and root out negative traits before they become deeply rooted. The program is also geared toward guiding each student toward his best potential.

Lloyds of London has been using graphology in its business dealings for over sixty years, and there's no more conservative firm in the world than Lloyds.

The CIA uses graphology as does the FBI, who denies it for reasons best known to themselves. In certain clandestine cloak-and-dagger circles, the waste-basket contents of rival interests are gathered and analyzed to learn strengths and weaknesses about political rivals, particularly of an embarrassing nature. Such knowledge of another's intimate personality that reveals chinks in his armor could be an invaluable lever in future dealings as most everyone has a skeleton or two of one kind or another hopefully locked up in the closet.

It is only natural that graphology should have its disclaimers. Its poor image in America is chiefly the result of the science having fallen into disfavor through being identified with quackery, the occult, tea-leaf readers, astrologers, whose daily forecasts apply to every person in the world born under a certain sign, and pseudo-graphologists who give one-shot analysis resulting from a punch-card machine at carnivals and county fairs.

All of the above have given the science a stigma identified with turban-wearing enigmatic "sees all, knows all, tells all" oracles sitting cross-legged in front of striped tents.

Graphology does not predict leisurely moon-lit ocean excursions to tropical, flower-scented climes, culminating in some romantic episode with some vaporous dream idol with the inevitable pot of gold at the end of the rainbow. The only thing graphology can predict is how an individual may be expected to react under a given set of circumstances. The discipline reveals the best and worst facets of personality, and those seeking an ego trip would be happier consulting a fortune teller rather than a handwriting analyst.

Most academician and layman disclaimers deny the accuracy of the science chiefly because of a subconscious fear of self-revelation, if the truth but be known. In addition to being a fascinating subject, graphology is also frightening, comparable to being on a par with window-peeping. As such, it isn't any wonder that those with paranoic guilt-complexes about some personal weaknesses would hotly deny and shun something that reveals the true inner being. It might be mentioned at this point that it is generally agreed among psychologists that the degree of one's guilt may be determined by the vehemence of his denials. The Watergate Case is a good example in support of this theory in that many who stoutly denied any connection later pleaded guilty when no further avenues of escape presented themselves.

Those particularly in entrenched positions do not like to have their snug ways of life threatened, and fear of self-discovery could have an ego-shattering effect by finally revealing themselves to be quite the opposite of what they pretend to be. Many high-placed individuals who demand a graphological analysis of subordinates for a wide variety of professional and business purposes do not themselves submit to a similar analysis.

Once a student has mastered the art of conducting an analysis, no one will ever be able to deceive him again. The tragic part of becoming adept at the science is that it totally removes the aura of mystique that surrounds individuals—particularly the glamorous type—and reveals their true inner being as opposed to what they pretend to be.

In his excellent book, HANDWRITING—REVELATION OF SELF, world prominent graphologist Dr. Herry O. Teltscher states: "World events and complex political situations at home and abroad demand that our political leaders possess the necessary intelligence, fortitude and character strength, and insight to cope efficiently with the vast array of national and international problems. The analysis of the handwriting of prominent statesmen and leading executives (with periodic check-ups for health reasons) would be of invaluable assistance to the democratic process itself. It is important that candidates for the highest office of the land and other statesmen considered for sensitive key positions in government possess the mental astuteness, the balanced judgement, the emotional stability, the talent for diplomacy so essential at the conference table. Similarly, the analysis of the handwritings of foreign leaders would aid in giving us the intimate know-how in dealing with them."

In this connection, the pathology of the late President D. Roosevelt at the time of his re-election to a fourth term was a good example of how a sick man can irreparably damage a nation's future for generations to come as indicated by his decisions during the Yalta Conference. A victim of an advanced neuro-vascular disease, he should have retired from office without further delay, as much in his own interest as in that of the nation.

Graphology, which is a social science, unlike mathematics, which is an exact science with hard and fast rules. Any science that deals with personalities cannot be exact as no two of us are exactly alike.

It seems that our Creator has subtly planted certain characteristics within our physical and mental beings that not only makes us unique, but which distinguishes each of us from our fellows, and which also provides researchers with a wealth of endless material regarding the mystery of man.

In his never-ending search for knowledge, man has found that no two sets of fingerprints are exactly the same. As a trained former fingerprint technician, this analyst has fingerprinted many sets of identical twins, and for the most part their fingerprint classifications were at wide variances. Fingerprints are accepted world-wide in court as positive proof of identity. Similarly, the legal system of all five continents is based on the assumption of the identity of the signature, and modern money transactions would be impossible if the least doubt existed that signatures could be disregarded in money transactions.

In a nutshell, fingerprints tell who we are. Handwriting tells what we are!

Police can determine the identity of an originator of an anonymous phone call by simply making a recording of the call, later making recordings of voices of suspects, then comparing results to obtain matching voice patterns.

It seems only logical that our Creator also provided man with the means of obtaining an insight into his character and personality by the evidence produced by the mark of his hand. The only mystery is why a certain stroke represents a certain trait, but exhaustive studies over the past 70 years keeps lending added weight to the fact that stroke formations do indeed reveal character traits.

Actually, the term "handwriting" is a misnomer. "Brainwriting" more accurately describes the action because muscular movements of the forearm, wrist and hand extended to the writing instrument are only incidental to the strokes: the direct projection of the writer's thinking. As mind is the builder, whatever is predominent in one's thinking will also be reflected in script.

It makes no difference how the writing instrument is held, the results will always be the same be it the right or left hand, between the stubs of the arms of an amputee; the mouth or toes of one born without arms, or the mechanical steel hook substitute for a hand. Education or lack of same makes no difference, nor does legibility or illegibility. The indicators will always be present to the experienced eyes of the analyst.

The only way handwriting can change—other than through a series of exercises recommended by a graphotherapeutist to root out corrosive negative traits—is for the personality to change for either better or worse, or as new skills are acquired or latent talents developed.

The uses of graphology are as varied as human experience, and may be applied to determining character, personality and aptitudes. Loan companies and credit managers may use it in connection with determining a loan seeker's responsibility toward his debts. Personnel managers can determine if a prospective employee is the right person for a particular position, or in finding those within an organization qualified for promotion to posts requiring leadership and managership ability. Parole and probation officials can determine if attitudes have actually changed in those seeking parole, and can keep current on their progress as well as the probation officer determining basic conflicts in youths brought before the board to decide on future action.

A pre-matrimonial compatibility analysis would save much future mental, physical, emotional and financial exhaustion. Love is indeed blind, and many rush into marriage for no more reason than physical attraction during a time when the lovers are putting their best foot forward to make a favorable impression. Quite often it is her sex appeal that is most desirable while she barters that for comfort and security. It is only after the honeymoon when guards are down that each returns to his true personality and troubles begin. Some couples are mature enough to adjust to one another while many cannot, thus resulting in all the disagreeable activities resultant to severing matrimonial ties. This tragedy is compounded when children are involved.

Individuals considering going into partnerships in a business could very well submit their respective scripts to analysis to determine if they could get along. Each could determine his best potential for their mutual benefit.

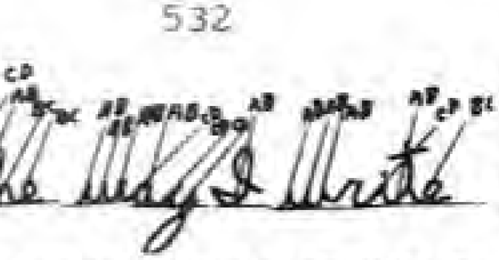
Psychiatrists learned in graphology claim that they can delve deeper into a patient's psyche from the evidence of a couple of pages of script than a month on the couch will reveal.

Medical graphologists are now determining the presence of cancer through script up to three years before it is detected medically.

Dr. Robert Neglar, professor of psychology at the University of Minnesota long ago adopted graphology as one of his favorite testing devices. He states that the science has repeatedly proven to be the quickest and most accurate testing device yet known.

And last, but by no means least, graphology may also be used as corrective therapy. By changing a negative stroke that could have a corrosive, psychosomatic influence on such a writer, and replacing it with a positive stroke, the deteriorating influence will eventually be eliminated, thus enriching the life and personality of the individual.

The script of public figures may be studied to determine if they are really sincere in their promises to the public, or if achievement to high office means only a lever to achieve their own personal whims. In the months to come the scripts of many past and present individuals will be closely examined among which will be the Kennedys, Nixon, Ford, J. Edgar Hoover, Carter and a host of others.

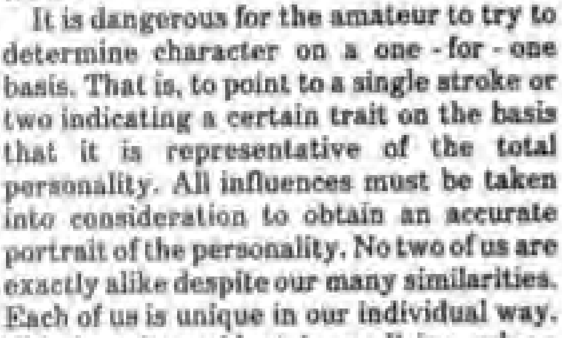


By D. C. Besly

Before getting into the many specific signs indicating traits that alert us to the deceitful, criminally inclined, the con-artist and troubled child, it is important to understand how emotions influence all traits.

It is dangerous for the amateur to try to determine character on a one - for - one basis. That is, to point to a single stroke or two indicating a certain trait on the basis that it is representative of the total personality. All influences must be taken into consideration to obtain an accurate portrait of the personality. No two of us are exactly alike despite our many similarities. Each of us is unique in our individual way. This is quite evident in medicine, where one remedy may cure while another has negative side effects. This uniqueness must be taken into account in evaluating character and personality.

The emotional nature is the foundation upon which all traits in a writer's character and personality trait is rooted in the emotions; the soil in which it developes, and which influences all other traits in the personality. The slant of handwriting reflects a writer's emotions; indicating the degree of expression and restraint.



The above is a reproduction of a transparent emotional gauge used to measure slant. One may obtain a protractor from any stationery or office supply firm. By using the above as a guide, determine the emotional response of themselves, their friends, relatives, children, business associates or whatever.

The gauge is placed upon handwriting with the horizontal line of the gauge coinciding with the baseline of the letters. Script written on unlined paper is best. Lined paper exerts an unnatural control with many writers unable to adhere to ruled paper. The analyst draws in his own baseline, then places the gauge at a point where a letter touches the baseline at its lowest point with the slant indicator emerging at the highest point of the letter, measuring only the upstrokes thus:

One hundred consecutive upstrokes are measured to obtain the predominent area of emotional response, or how the writer may be expected to respond most of the time. You may draw your own conclusions regarding the above specimen after you've read further.

For now, we will be concerned with explaining the various areas of emotional response as they influence the personality.

The F minus slant, very reclined, indicates emotional response ranging from low to complete indifference. Reactions are repressed, behavior evasive, attitude generally reluctant. Interests are chiefly egotistical. Such persons are independent, hard to get along with, difficult to fathom.

The F - A, reclined slant, indicates the introvert. A cold exterior masks inhibited feelings. Attitude will be diplomatic if script is superior, hypocritical and insincere if inferior. In general, the backhand is undesirable. Individuals who write that way are too reserved, often indecisive, not straightforward, and sometimes contentious. Self - interest is a dominating factor in this area. These persons are chiefly concerned with how they may benefit from others. Their attitude is not what is the best course, but "What's in it for me!" These individuals are often quite capable of putting on a convincing act of friendliness, gregariousness and sympathy for appearances sake, but it is chiefly a pose for effect and personal gain. It may be detected by the unnatural backhand slant, a type of script that is definitely negative while also revealing withdrawal. Backhand is not taught in any school of penmanship. Both the F minus and F - A slants are beyond poise and judgement. These persons construct a shell of isolation about themselves and withdraw from the world in general, and as in the case for women, chiefly marry for comfort and security. A test conducted several years ago by a leading international graphology society revealed that the F minus and F - A slants composed a small minority of 5.3 percent of those tested.

The A - B slant represents vertical writing. Objectiveness is indicated. Mind over matter. The head rules the emotions. The subject has complete self - control. The attitude is apt to be undemonstrative, independent, detached, even indifferent. The keynote is cautiousness. Self - interest is still the dominating factor. Such writers are more interested in the "I" than the "You!" They seek the best course to follow. This area of emotional response makes up about 13.6 percent of the study group. President Lyndon B. Johnson's script was chiefly objective. He was also an aggressive arm - twister as well.

B - C slant. Lightly inclined. Signifies a normally sensitive and healthily emotional, well - balanced person when handwriting is superior; when inferior it generally shows mediocrity and conformity. This area of emotional response has been described as the slant that reveals the best marital partners because it is half - way between the two extremes of reclined and inclined script: euphoria and hysteria. However, there are two sides to the coin regarding all character and personality traits. In one respect we have the controlled mind softened by sympathy. On the other hand the emotions are held in check by the controlled mind. In other words, we have a collision of thought and feelings, which evaluates to ambivilence. This latter can evaluate to a split personality, or schizophrenia under certain conditions. This is nothing to become particularly alarmed about as many of us have this characteristic to a greater or lesser degree from a mere trace to predominent, depending on circumstances. Research has revealed that the B - C slant has been found to be the chief writing slant of forgers and confidence artists who use their wits for deceptive purposes, and makes up about 14.0 percent of the study group slant. It is the chief slant of Senator Edward Kennedy.

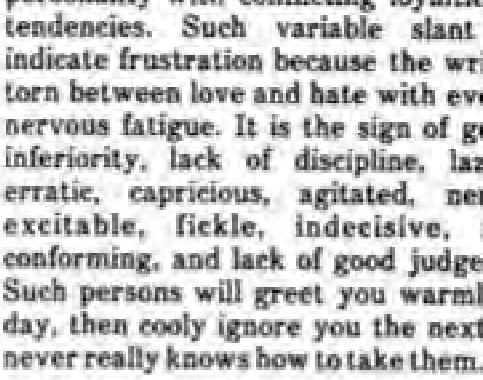
C - D. Inclined. Signifies an ardent, affectionate, amiable, very sensitive and emotional nature. This slant makes up about 15.7 percent of the study group.

D - E. Very inclined. Signifies an intensively alive, ardent, passionate, responsive, susceptible individual. Often a veritable brush fire when supported by great depth of emotions. Also signifies one who frequently jumps to conclusions before having all the facts in hand, and who reacts immediately, instinctively, without thinking and upon impulse. Such a writer will often say and do things on the spur of the moment that are later regretted when ample time to cool off has passed. Such writers are inclined to over - react, and often express themselves through a variety of physical gestures. This area of response is the most predominate among individuals, and represents 33.0 percent of the study. One may witness the conduct of the impulsive at political rallies and sports events by the cheering, yelling, stomping, waving of arms, whistling, applauding, screaming, jumping, swarming onto playing fields to beat their heroes on the back or murder the opposing team. Madison Avenue advertising writers are well aware of mass childish impulsiveness, and exploit this potential customer weakness to the seller's advantage with clever slogans and attractive packaging. The familiar bosomy, bikini-clad sex goddess pictured on a wide variety of men's products as always been a successful come-on promoting sales if for no other reason than to get the picture and fantasize. One need but stroll through a super-market to observe housewives impulsively grabbing with both hands to fill shopping carts to overflowing with junk foods. The traits of gullibility and submissiveness further lend support to impulsiveness. If you are the impulsive type, learn to control it. Later articles will cover such methods of control.

E and E plus. Acutely inclined. Signifies one who is fervid, excessively romantic, passionate, jealous, easily offended, demonstrative, excessively romantic, a veritable volcano; and in certain instances, hysterical. In fact, hysteria is perpetually smouldering beneath the surface awaiting the proper set of circumstances to trigger it. The occasion, luckily, may never arise, but it is always present. It must be taken into consideration if the slant is predominate or merely occasional. One whose slant might measure fifty percent or more of the script would be more apt to lose control than one whose slant measured less than a dozen strokes. The weaker or stronger a trait, like all other traits, the more or less likely the change of expression. The hysteric exaggerates and over-dramatizes every ailment and difficulty, and is likely to lack deep ethical feelings. Former President Nixon had strong presence of hysteria in his script. Nixon's personality will be covered in a future article. Of the seven areas of emotional response found in personality, the E and E-plus is the second most predominant area of emotional response, and makes up 17.5 percent of the study.

The above indicates the masses are chiefly impulsive, jumping to conclusions without having all the facts at hand, or are hysterical, having the capacity to lose self-control under extreme emotional experiences when facing a crisis. Not exactly an encouraging picture, but something which may be hopefully corrected when educators finally realize the harm that has been done for centuries by the built-in auto-suggestion inherent in the school copy-book method of penmanship that reflects the negative qualities of those who designed the exercises. After all, penmanship teachers are not graphologists, more the pity. If we are to survive, we must learn self-control!

Constantly changing slant. Writing that reflects a variety of slants indicate the unpredictable individual. These persons are like a reed in the wind that bends every which way with each vagrant breeze. Ambivilence is present along with contradictory inclinations: to yield or to protest; remembrance of things past and hope for the future; resignation and optimism; opposition and assent; selfishness and altruism. There may be a split personality with conflicting loyalties and tendencies. Such variable slant may indicate frustration because the writer is torn between love and hate with eventual nervous fatigue. It is the sign of general inferiority, lack of discipline, laziness, erratic, capricious, agitated, nervous, excitable, fickle, indecisive, non-conforming, and lack of good judgement. Such persons will greet you warmly one day, then cooly ignore you the next. One never really knows how to take them.



SURVIVE THROUGH HANDWRITING ANALYSIS

D.C. Besly

Shortly after he left the presidency, a press release quoted former President Richard M. Nixon as stating, "We, as a country, have to provide strength and leadership."

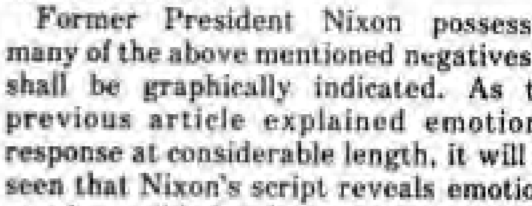
This from a "leader", whose capacity for leadership was about as low as it is possible to get, and who is least qualified to discuss the subject.

Leadership, the ability to assume command is very often filled by those who do not possess the ability to any great degree. They have achieved their positions by having been in the right place at the right time when it was necessary to fill a managership vacancy with whatever material was at hand. For the most part, history reveals that the world is and has been run by mediocrities who have arrived on the basis of a small talent, or who were the tools of higher-ups, sworn to carry out the programs of special interest groups.

Leadership is the sum of many parts. First of all there should be education, training and experience. A leader cannot indulge in self-consciousness, self-centeredness, or be greedy. There should be no lust for power or to domineer. There should be a capacity for diplomacy free from the taint of hypocrisy; initiative, and the ability to organize. There should be a need for responsibility with the competence to handle responsibility. There should be broadmindedness—respect for the opinions of others—practicality and unselfishness.

A leader cannot be emotionally or mentally unstable, have temper, irritability, conceit, be ill-mannered, ostentatious, vain, a show-off, egotistical, or hold a grudge even when challenged. A good leader is one who himself has first learned to take and carry out orders, and should possess no defiance to higher authority or hold resentment.

Former President Nixon possessed many of the above mentioned negatives as shall be graphically indicated. As the previous article explained emotional response at considerable length, it will be seen that Nixon's script reveals emotions running wild for lack of control. The extreme E plus slant gives unimpeachable evidence of this. Here is emotional instability. As previously pointed out, the hysteric exaggerates and over-dramatizes every difficulty and ailment, and is likely to lack deep ethical feelings.



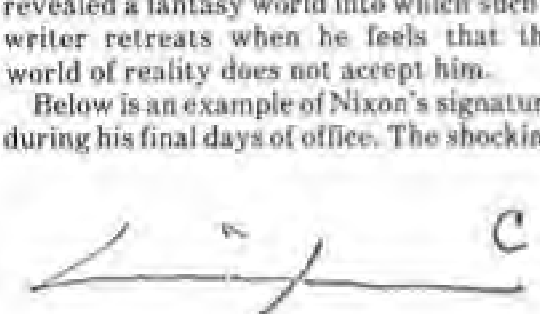
An over-inflated ego is indicated in the above by the super-elevated capital letters indicating a God-like self-image. Capitals two and one half times the height of middle zone letters denote the egotistical, conceited person. The higher the capitals the stronger the trait. Here is one loving display with a strong sense of exaggerated pride evaluating to vanity. Vanity is self-love, and as such admits to no faults or mistakes.

That Nixon loved display was evidenced by the pomp and ceremony surrounding White House activities such as the comic-opera uniforms the security forces were outfitted with in assuming a "palace guard" image following one of Nixon's visits to Europe where some remnants of decadent royalty still exists. The band always struck up "Hail To The Chief" each time he appeared in public along with trumpeters sounding "Ruffles and Flourishes". If any president was ever a bloated ham for theatrics and attention, Nixon took first prize.

Additional evidence of Nixon's lack of touch with reality is found in the super-elevated small letter "d" in the first name. Graphologically, the small "d" indicates the presence or absence of pride, depending on height. In this instance, it indicates vanity gone wild. Upper loops represent the abstract imagination: plans, ideas, theories, and spirituality if other supporting traits are present. The different height of the upper loop of the small "h" as compared with the small "d" are inconsistent, indicating theoretical instability.

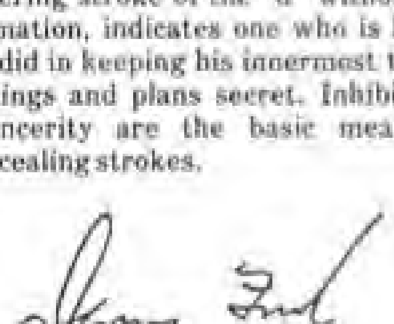
The extreme height of the "d" reveals a power-drunk vanity that is reaching beyond its grasp. Vanity seals off one's guilt sense. It is pseudo self-esteem, and as such is above the law that governs ordinary folks. Such a writer's thoughts are not dominated by sober thinking, while at the same time the unusual height reflects unrealistic idealism and flights of fancy and illusions of grandeur. Here also is revealed a fantasy world into which such a writer retreats when he feels that the world of reality does not accept him.

Below is an example of Nixon's signature during his final days of office. The shocking



change reveals personality deterioration, aided and abetted by an extremely emotional being who could not stand up well in the face of a crisis. Hysteria overcame the super-narcissist. Maybe someday the masses will cease to judge every aspiring politician in terms of Simon-pure morality that is even rare among the clergy.

Just a cursory examination of Jerry Ford's signature reveals unrealistic ambitions parallel with Nixon's. Here again is the God-like self-image of the over-inflated ego along with the small letter "d" reaching beyond its grasp, or "out of this world" to quote the moderns. The up and down covering stroke of the "d" without a loop formation, indicates one who is less than candid in keeping his innermost thoughts, feelings and plans secret. Inhibition and insincerity are the basic meanings of concealing strokes.



Like the formation in Nixon's first name, the exaggerated height of the "d" reflects unrealistic ambition and flights of fancy. Ford has already admitted that he "misses the White House". No doubt the absence of a cheering, handshaking public has made itself felt. Once a politician has fed at the public trough, he never seems to get over it, and often tries and tries again following a loss of office.

The jerky movement of Ford's script lacks rythm, reflecting his accident prone clumsiness in repeated falls, bumping his head and dropping things.

Nixon chose his successor well. Ford's pardon of his crony was a skin graft over a cancer. Nixon put Ford in office so one hand could wash the other. Ford was the politician closest to Nixon's policies.

The glaring similarities in both the Ford and Nixon signatures give unimpeachable evidence that these two birds of a feather were cut from the same cloth! Additionally, that weird configuration of the lower loop of the capital "J" in Jerry, along with the triangular pointed formation of the small "y", indicates the bedroom athlete. Any complex, diverse configurations in lower loops reveal erotic fantasy that takes unconventional forms.

For the moment, it should be remembered that any exaggeration in script indicates abnormality.

The diverse formations of the same capital letters: "J", "E", and "C" in the Carter signature reflects a dual, or split personality. This rule always applies when letter formations are written in diverse forms. The last name, Carter, tends to taper like a wedge from the "a" to "r". This tapering indicated presence of diplomacy.

For the most part, diplomacy has always been regarded as an admirable trait. A trait often used to gain one's points, evade an issue, or avoid a busted nose and loosened teeth. I maintain the positives will take care of themselves nicely. It's the negatives one has to be alert for in order to survive this competitive, cut-throat rat-race. When one becomes familiar with the negatives and how they influence character, then we are better prepared to deal with them in protecting ourselves. So here goes with all the stops pulled out!

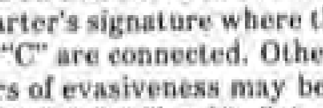
A diplomat has been described as one who "remembers a lady's birthday, but forgets her age." A diplomat—whether the suave, morning-coated, striped pants type representing matters of state, or a seducer using soft soap to charm a victim—is one who is adroit in dealing with people. The diplomat is skillful in negotiations, and can maneuver successfully and without friction in difficult situations.

The true purpose of diplomacy is to prolong a crisis by pouring oil on troubled waters. Other terms for the trait are: dissimulation, cunning, pretense, feign, artful dodger, machination, double-cross, chicane, hocus-pocus, knavery; take your pick. In the presence of evasion, secrecy and downright deceit, diplomacy evaluates to hypocrisy.

Remembered statements of former Secretary of State, Henry Kissinger were masterpieces of evasion. He chiefly spoke without imparting information of any significance. Some examples were, "We have made significant progress. Our views are in complete accord!"

Most bureau chiefs along with presidental press secretaries have a well-cultured talent for speaking bureaucratese—that frustrating native Washington dialect that uses long words and complicated sentences to convey practically nothing. Regardless of any speaker's position, any listener to such verbal beating about the bush should be immediately alerted to the fact that such speakers have something to conceal.

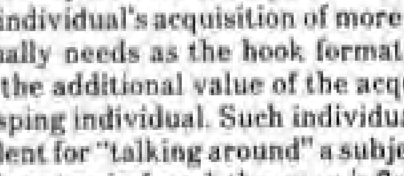
As previously stated, diplomacy may be recognized by tapering words and letter forms, thus:



The Tapering of Diplomacy

Graphic indicators that lend diplomacy that taint of hypocrisy are: evasion, self-deception, secrecy, intentional deceit, lack of emotional control and fluctuating moods. Any one or all may color diplomacy's effect.

Evasion is recognized by the double hook in letters as evidenced in the first capital "C" in Carter's signature where the capital "E" and "C" are connected. Other graphic indicators of evasiveness may be found in the small "a", "c", "d" and "g," thus:



Double Hooks of Evasion

The evasive individual maneuvers to obtain desires not by expressing an untruth, but by evading the truth. Its presence indicates a deep-seated feeling of insecurity which can only be overcome by the individual's acquisition of more than he actually needs as the hook formation also has the additional value of the acquisitive, grasping individual. Such individuals have a talent for "talking around" a subject.

Here too is found the over-inflated ego represented by the over-large capital letters along with the super-elevated small "t" in Carter. Here again is the unrealistic idealism and flights of fancy reaching beyond its grasp that were so much in evidence in the Ford and Nixon signatures.

Significant is the lack of i-dots in Jimmy, revealing carelessness with details. Those who omit i-dots lack well-grounded ethical ideals. The very low placement of the t-bars reflect extremely low goals and vision so necessary toward planning long range programs so important to good leadership. Carter does not think very far into the future, a thing that seems consistent with far too many former chief executives who were more concerned with the immediate now and feathering their own nests than with the nation's general good. The t-bars are extremely weak, showing a decided lack of will-power. Carter can be easily pressured. His choice of cabinet members and aids indicates this weakness.

I know of no analysts who have mentioned the presence of shark's teeth in Carter's signature. Easily overlooked in script, shark's teeth are characteristic of those whose business it is to profit, broadly speaking, through people's credulity. Prominent analyst Billie Rosen states that the writer of a certain type of "m" is a dangerous person. It is typical of the person who wants to profit through the gullibility of others in outsmarting them. It takes naivete to fall prey to the shark's tooth writer, and whenever a naive person and a shark's tooth writer meet, the former is in for some quiet, systematic and pitiless bloodletting. Americans are the most gullible persons on earth, chiefly evaluating a person by what he seems to be as opposed to what he really is.

Shark's teeth may be seen in the final small "m's" in James and also Jimmy where the final top stroke ends then comes leftward in a curve that resembles its namesake. Checkmarks have been placed to call attention to the significant area, thus:

Shark's Tooth "m"

The spacing of disconnected letters between the "t" and "e" in Carter, and the "i" and "m" in Jimmy reveal intuitiveness: the capacity for very rapid deduction from an instantaneous observation. Carter revealed this quality during his debates with President Ford whose performance more closely resembled an akward, tongue-tied bumpkin with an accident-prone mind as well as body.

Intuitiveness infers keen and quick insight resulting from immediate perception and comprehension. (This does not mean that intuitiveness is infallible. The discoveries of intuition have always been developed further by sober reflection and logic. In ordinary life, intuition is a powerful but dangerous means of acquiring knowledge. Sometimes it can hardly be distinguished from illusion. Those who rely upon it entirely are liable to mistakes. It is far from being always trustworthy, depending upon likes and dislikes, bias and predjudice. But the great man, or simple soul whose heart is pure, can be led to the summits of mental and spiritual life by its strange quality.)

Here we evaluate intuitiveness with evasion, diplomacy and shark's teeth, and the result is instinctive cunning. It will be interesting to observe the future. Citizens should not look forward to that ever-sought eventual pie-in-the-sky paradise with great rewards for little or no physical effort. Politicians have been promising this dubious state of affairs for as far back as I can recall, but things keep deteriorating in spite of all mortal man's think tanks and brain trusts can do about it.

Leadership? What do you think!

An Effective Trap with Live Bait

From Popular Mechanics 1928

I have used a number of different kinds of traps but the most successful of them is that shown in the drawing. Many small fur-bearing animals are fond of chicken meat. The fox will catch a chicken and carry it off, the mink and weasel will cut the throat and bite the head, etc., and a coon will catch one if he has a good chance. I give them a good chance, or at least they think so, by baiting my trap with a live chicken. The way I do it is to make a box about 12 in. square and 3 ft. long. This box is made of old lumber so that the animals will not be suspicious of it. Each end of the box is covered with wire mesh, the wooden ends being removed entirely. The mesh at one end is attached to a frame hinged to the box to permit putting a chicken in and taking it out. Two more boxes are made of similar size with one end screened securely, and a screen trapdoor fastened in the other end. The three boxes are then taken to the place frequented by fur bearers. The chicken is put into the center box, the hinged end is securely fastened, and the boxes are then placed in a row with the chicken box in the center as indicated. The trapdoors are set and all is ready for the catch. At night an animal will try to get the chicken by crawling into one of the end boxes. Once in the box the door closes and it is caught. The chicken box is long enough to prevent the animals from molesting the chicken in any way, except frightening it. This is the only way I ever was able to catch a live fox without hurting it. I have caught several this way and mink, weasel, coon and even an opossum will occasionally crawl in.

Three-Compartment Trap Capable of Holding Two Animals, the Center Box Being Baited with a Live Chicken

From Modern Mechanics 1934

Vacuum Powers Vertical Windmill

SIXTY per cent of the power developed by a new vertical windmill is derived from the vacuum formed by the vanes.

The vanes of the power mill are shaped like airplane wings, thereby making use of vacuum as a power generator, the inventor claims. The mill will develop 20 horsepower in a 15 mile an hour wind.

The windmill was designed to generate power for pumping operations near Bellflower, Calif. Each vane is 12 feet long and three feet wide and is made of lightweight metal. Vanes are mounted on a tubular structure that rises far above surrounding roofs.

The vanes on the above vertical windmill are shaped like airplane wings to form a vacuum to generate more power.

 THE SURVIVOR Vol. 2

The Survival Mentality

By Paranoid George
(Co-hero of WHEELS OF RAGE)

SAVING AND HAVING

"Either man must be content with poverty all his life or else be willing to deny himself some luxuries, and save, to make the base of independence in the future. But if a man denies the future, and spends as he earns (whether his earning be one or ten dollars a day) let him look for lean and hungry want at some future time, for it will surely come, no matter what he thinks. To save is absolutely the only way to get a solid fortune; there is no other mode. Those who shut their eyes and ears to these plain facts, will be forever poor, and for their obstinate rejection of truth mayhap may die in misery. Let them so die and hang themselves. But no. They take a sort of recompense in cursing fortune. Great waste of breath. They might as well curse the mountains and the eternal hills. For I can tell them fortune does not give away real substantial goods. She sells them to the highest bidder. Men never make so fatal a mistake as when they think themselves captives of fate—'tis the sheerest folly in the world. Every man may make or mar his life, whichever he may choose. Fortune is for those who by diligence, honesty and frugality place themselves in a position to grasp hold of fortune when it appears in view. The best evidence of frugality is the five hundred dollars or more standing in your name at the saving bank. The best evidence of honesty is both diligence and frugality."

The above words were printed one hundred years ago, on May 13, 1877 in THE HUMBOLDT TIMES. At that time Humboldt County was a vital and developing sector of Northern California. In those days, especially in the western states, America was still a young and vigorous nation, peopled by energetic, practical men and women. They lived by the tenet, "If you need a helping hand, you'll find one at the end of your arm."

Neighborly sharing and cooperation were valued and necessary, but an individual's prime responsibility was to be self-reliant and productive. In that way he became an asset to the community and earned respect. People were held to be responsible for their own futures. Thus, a truly progressive society was built, morally and materially.

Today, however, Humboldt County has become modernized. The area now swarms with welfare recipients and the county is dependent on continuous Federal funding to avoid depression conditions. And so goes the rest of the nation.

Today, any local newspaper bold enough to print an editorial like "Saving and Having" would be deluged by indignant letters from Liberals and welfare recipients alike.

Our present welfare-oriented society confuses degeneration with progress. We are told that the idea that everyone should pay his own way is both archaic and heartless. That those who produce should be forced to guarantee the futures and opportunities of those who neglect to plan and provide for themselves properly, and we support the vast and ever-growing sub-culture of the parasitic Welfare Class.

Indeed, the Welfare Class has become a major power block in America and its members are self-righteous and assertive in demanding a better and more bountiful standard of living. It is provided, of course, by forcing those who do produce to support them by ever-increasing taxes.

A century ago it was no fun to be a freeloader and all but impossible to survive as one. Unheard of were the Federally funded programs to take the misery out of poverty and to support able bodied welfare leeches. Those who would not, or could not, produce, simply did not survive to demand a free ride from productive citizens. If a citizen was dissatisfied with his standard of living, there was every incentive to better himself by saving or learning a useful trade needed in the community. He knew that if he didn't care about himself, nobody else would.

In contrast are the arrogant welfare lice today, backed by the Liberal creed and a sense of deserving. It interests me sometimes to hear what some of these pathetic parasites have to say about life and the world. And so I found myself talking to a typical welfare brood sow who was "on the county" as she put it.

Well over 200 pounds of bloated pork, this able-bodied young woman was a second generation welfare case. She wore a garishly colored tent-like garment and her hair was frizzed out, looking like a used Brillo pad. Between sentences she stuffed her mouth with potato chips from a large box at her side. In one hand was a king-sized beer. From the next room came the foul-mouthed cacaphony of her two whelps at play, undernourished, in contrast to their gross mother.

"It's a rotten life and a stinking society," she asserted.

"Oh," I said. "And what's stinking about it?"

Well, if you was on Welfare you'd know how it is to be poor," she accused. "On the first and fifteenth of the month I get my checks and I can have a good time and live right for a couple of days. But after the party's over and the money's spent, all's I got is my Food Stamps."

"All you can get with them is grub, and I'm on a diet. So I have to sell them so I can get cigarettes and beer to last me. But I think I'm pregnant and at least that'll mean a raise. At least Medi-Cal pays my medical bills and I live in Government housing. But Hell, you can't spend that. I want to live decent; at least they owe me that much!"

When I suggested that perhaps she could get a job and get out of the Welfare rut, and perhaps ask the father of her kids to help with their support, she exploded with indignation.

"If I got a job they'd cut back on my Welfare and I'd be no better than a nine-to-five chump and be working my tail off for $2.50 an hour. If you'd ever been on the County yourself, you'd be smart enough to know that.

"And if I had some pair of pants supporting me and my kids, they'd cut me clean off Welfare. What do you think, I'm stupid?"

I asked her if she didn't feel ashamed that a lot of people do work at low income jobs and get no Food Stamps or Medi-Cal, who have to pay taxes so that she could get Welfare while refusing to work.

"That's their problem," she snorted. "I have my own life to live. And don't give me any of that work ethic jive. That went out with high button shoes."

Indeed it did. And that is why today's society is saddled with a vast herd of worthless human baggage who would never have survived a century ago, amid the vigorous, survival-oriented communities of our grandfathers. People who looked to their own ingenuity to cope with disaster, not dependent on giveaway programs to survive.

Yet, Nature has a way of cleansing itself. And when our highly technological society collapses due to its incompatibility with the laws of Nature, the gravy train will grind to a halt. Then the Welfare masses will simply starve. Also decimated will be the ranks of the unprepared, geared only for survival in the present artificial environment of our cities. Technology will then revert to that of the 19th Century. Morality must likewise follow.

Survival will be the province of those who, like the clear-thinking and productive men and women, once built functioning, bountiful communities many years ago. They had the wisdom to realize that there can be no permanent place for parasites.

The Ticket to Mental Health for Survival

By Paranoid George

(Beginning with a short excerpt from WHEELS OF RAGE)

"When they got back to the mausoleum the other two ghouls had left. In his drawer, Paranoid George was kicking and screaming and trying to get out. If they hadn't gone back for him he could never have gotten out.

"When they opened the drawer he sat up with his empty gallon wine bottle. He was slobbering and was out of his mind. He was so drunk that when he woke up in the darkness and couldn't get out he actually believed he had been interred. He clambered out of the drawer yelling, 'Buried alive! Buried alive!'

"Then he ran out to his bike and roared off into the night screeching over and over, "Buried alive!"

"Big Mike and Pinochio left Gargantua with his bent up machine and went to get the camper. They came back soon and loaded up Gargantua's scooter. Then they all went home to Big Mike's and partied the rest of the night waiting for Paranoid George.

"When Paranoid George made his way out of the cemetery he wandered around for quite awhile before finding his way back to Glendale. He was cold and drunk. Feeling a maudlin need for some warmth and spiritual comfort he stopped by a Catholic church and parked his bike.

"He went up the broad steps and opened the door and looked inside. There was no one around so he went into the lobby and peered around the corner at the altar down in front of the church. There was a priest busy arranging some candles and a couple of worshippers kneeling in prayer.

"Stumbling around sadly like the beaten sinner he was, he found an open confessional and went in and sat down. To his credit, he didn't know where he was. When he closed the confessional door its darkness might have reminded him of the crypt but there was a grille in the side for the confessor to talk through. It let in just enough light to make the place cozy.

"Soon he slumped over and went fast asleep. Sometime very early the next morning he accidentally hit the switch turning on the lighted sign which read, 'Priest is in.' It was probably because the light was on that no real priest opened the door to the confessional.

"About seven o'clock a beautifully built girl sat down at the grille and began her confession. 'Father forgive me for I have sinned.' Paranoid George woke up to hear the girl going on to tell about what she had done with, to and for her boyfriend last night. He listened in amazement as she described positions he could only imagine in a motorcycle pileup. She painted a picture that would make the average skin flick look like an old Victorian morality play.

"Paranoid George still had no idea where he was. All he knew was that a girl he could barely make out through the grille was telling him the horniest story and had to be hot and wanting him.

"When her message was only too clear to him he said, 'Okay, baby, let's make it. My place or yours?'

"For a minute the girl couldn't believe what she heard. When it finally registered she started screaming and going into hysterics. That brought five priests and a bunch of citizens running. She pointed to the confessional and shrieked, 'That goddam priest in there propositioned me!'

"The citizens were shocked and the monsignor who was with the priests jerked open the confessional door. When the priests got over their amazement at seeing Paranoid George sitting there in his black robe and vampire makeup they dragged him out and stood him on his feet.

"When the girl got a good look at him she hollered, 'I confessed to that? Jesus, God Almighty; what is it? It looks like a Muppet!'

"The monsignor shouted, 'Young man, how dare you sit in there and take a confession. You're undoubtedly disturbed. Made up like that you must be against everything the Lord stands for. You must be some kind of devil.'

"No I ain't," Paranoid George raged. 'I'm a Christian. I was saved at a showing of Elmer Gantry.'

"Then he turned and bolted out of the

church. He hopped on his scooter and tore off down the street yelling, 'Buried alive! Buried alive!'

The foregoing is a scene from chapter seven of WHEELS OF RAGE, by Kurt Saxon. The book is about the Iron Cross Motorcycle club and our zany adventures. Those of you who have read it will remember me as an off-beat, often comical character.

But there was nothing comical about the paranoid, sometimes bizarre, thoughts and feelings which constantly tormented my fevered brain. Thus triggering most of the looney behavior which earned me the nickname of Paranoid George. Common sense will tell you that most people who have to get drunk or high before they can have a good time, and those who must indulge in hostile, anti-social behavior in order to feel fulfilled are often tormented individuals.

In my case it was the paranoid feelings of persecution that drove me to drink all the rot gut Red Mountain Burgundy I could chug down my gullet. Also to wind up doing 90 days in the pound for stomping some naughty old coot who I figured was trying to get queer with me.

If you are a troubled soul, your problem might take the form of spells of depression, unexplainable anxiety, outbursts of temper, or maybe just a growing feeling that people don't show you enough respect. In any case, you are very unhappy. Your inner feelings may tend to result in social behavior which others see as wierd. They begin to see you and react to you in a negative way. You sense this reaction and become even more frustrated and begin disliking people. This of course results in additional anti-social behavior, be it verbal or physical. Or you may just withdraw into your own little world. This syndrome is no fun, as I know, having been through it myself.

For example, up until recently I used to wear sunglasses with two-way mirrors for lenses. That's because I felt people were staring at me. In the past I'd have a compulsion to stare at a person every few seconds to make sure he wasn't staring at me. Not wishing to tip my hand by exhibiting my own odd eye action, I began wearing the glasses. In this way I could check out any suspected starer in, say a waiting room, up to 50 times without letting him know I was looking at him.

Unfortunately, I found that one of the best ways to guarantee plenty of people giving you funny looks is to go around wearing specs with two-way mirrors for lenses. As you can imagine, I began to find lots of proof that I was being stared at, especially when I'd show up wearing those sunglasses indoors or on rainy days.

As time went on, things got worse and I felt that my enemies were gaining on me. Indeed, they were my best friends. At night I developed insomnia. Sometimes I sensed a vague warning bell inside me that the chick sleeping next to me might turn into a giant spider as soon as I drifted into dreamland where nightmares were the norm.

When things began to reach their utter madness, I became afraid to be alone. But I was also afraid to be with people. I developed a terror of elevators, airplanes, mirrors, cancer, heart trouble, the dark and the supernatural.

After much introspection I came to the conclusion that all my problems were the result of a black magic curse upon me by a wizard who was masquerading as a faggot in Glendale, California. When I reached the point where I began to have hallucinations, I determined to put a stop to this persecution. After I found that stomping him did no good, my further plans of attack included contacting a sorcerer to make up a counter-spell which would save me from cutting his head off. In a word, I was nuts.

If any of this sounds like you or a friend or loved one, whether you feel you're reaching the point of no return or simply exhibiting some of the milder, though unpleasant, neurotic thought patterns, take heart. You may be merely suffering from a condition which you can correct within minutes.

The chances are great that you, like myself, can find glowing mental health and tranquility. It may come so soon and so easily that you may be amazed, as I was at my own speedy recovery. As I write these words, I sit here with a peaceful, anxiety-free feeling. I feel generally good these days. Gone is the erratic behavior, crazy thoughts, nightmares, insomnia, depression, and paranoia. I threw my reflecto specs in the garbage last week and I feel fine.

At this point you may expect me to thank Freud that I sought expert psychiatric help in the nick of time. Or that I'll endorse Trancendental Meditation or even self-control.

Not at all. In fact I took psycho-therapy for six months, as an alternative to a jail sentence. But I was so paranoid that I wound up accusing my therapist, a patient and personable young woman, of being a secret bull-dyke who was plotting to get me committed to a nuthouse on behalf of womens' lib.

What did cure me, however, was fructose and niacin. As a result of taking these I've started thinking straight. And I no longer suffer from the CHEMICAL IMBALANCE which had in fact been the real cause of my so-called mental problems. I have a niacin deficiency brought on by low blood sugar.

I make no pretense to being an expert in the field of psychology or even in nutrition. I do, however, know what has caused a miracle in me and have since observed niacin and fructose work on other secret squirrels with amazing results.

I don't blame you if at this point you are a bit skeptical. My first experience with niacin and fructose came one evening when, as usual, I was going crazy and beginning to hallucinate. If someone had told me then that after dropping 600 mg of niacin and couple of teaspoonsful of fructose I'd be perfectly normal, I wouldn't have believed it. Yet, that's exactly what happened.

I'd recently moved to Eureka to go to work for Kurt Saxon on the staff of THE SURVIVOR. One night I was at Kurt's place and we were sitting around drinking beer and enjoying light conversation. For no particular reason I suddenly got the idea that Kurt was crazy and he planned to poison me, work black magic on me and in general had ideas about doing me in. "He can't do me in, man," was my exact thought.

But the most alarming thing I noticed was that his forehead suddenly seemed to be increasing in height while his face started getting smaller. At the same time, his eye movements and gestures appeared to get quick and erratic. His whole appearance was rapidly changing into that of a super-looney psycho who resembled Emperor Ming from Flash Gordon. The guy seemed to be going bananas right before my eyes!

"Hey," I demanded, "what the hell is going on here? You can't fool me. You're planning some rotten scheme and I won't put up with it!"

Naturally the conversation deteriorated rapidly at that point and the recriminations flew thick and fast.

Somewhere along the line, Kurt started talking about niacin and fructose as a cure for depression and paranoia. He produced a small plastic bottle of what appeared to be aspirin and a jar of fruit sugar, or fructose. He then suggested that I might have a niacin deficiency. I didn't believe it.

But about then I was ready to try anything, even if it was to prove it didn't work. So I picked up the bottle and shook six of the little white tablets into my palm. Tossing them in my mouth, I downed them with a couple of gulps of Colt 45, followed by a teaspoonful of fructose.

The first thing I experienced was a burning sensation that felt like a sunburn all over my body and I thought I'd been poisoned for sure. I looked in the mirror and saw that my face had turned beet red, exactly like a sunburn. I later learned that this is a harmless reaction caused by the niacin releasing trapped histimines in the body. It's called flushing.

Along with this flushing I suddenly experienced a wave of carefree self-assurance and tranquility. My thinking became crystal clear. My paranoia and visions of plots and poisonings had vanished in seconds. In fact, I could recall my crazy mental process of a few minutes before and I felt free and confident to discuss my former wierd ideas. I laughed at them as the absurd delusions they were.

The effect of the niacin and fructose had been dramatic. And though I didn't know it at the time, the high that I experienced was merely the feeling which most people have who are not chronically depressed. In any case, I'd been cured of lifelong depression and paranoia in ten minutes.

These days, instead of taking six niacins like the first time, which was too much, I just take one and a level teaspoonful of fructose every few hours, especially if I begin to feel low.

I'm told by a nutritionally oriented psychologist that the effect of niacin on most people is not usually so sudden as it was with me, though the result is the same. Usually a reserve has to be built up over the period of two days to a week. But it works.

So if you have periods of anxiety where you feel something is wrong without really knowing what, or get depressed for no readily apparent reason, niacin and fructose may be all you need. Tranquilizers have the same effect on depression and paranoia but they just suppress the wild imaginings without healing the system, as is done through the use of niacin and fructose.

Consider the probability that you may have a niacin deficiency like I have. If you do, you're actually among the lucky. Niacin can be bought at any drug store without a prescription. It's just a vitamin and sells for a little over a penny per 100 mg tablet. Fructose is simply fruit sugar and can be bought at any health food store for about $2.00 a pound.

When you get a flushed feeling from niacin it simply means you've taken more than your system can handle at that time. try one 100 mg tablet and a level teaspoon of fructose. If you don't get flushed or feel better within 15 minutes, take another tablet and some more fructose. If even one tablet is too much, break it in half. In a short time you'll know how much to take to feel better without flushing. It won't be long before you build up a niacin reserve and then you can take one tablet and a spoon of fructose whenever you feel depressed, anxious, enraged over some small aggravatión, etc.

Often when a person is depressed and anxious, his feelings signal his adrenal gland to release adrenalin for fight or flight. But since there is no actual problem worth fighting or running from, he is left with a feeling of impending doom coupled with impotent rage. Then he clobbers some dude, or beats the wife and kids, or starts shooting up the neighborhood and gets the SWAT team in. This works the same on women and is the main cause for child battering.

What fructose does, in combination with niacin, is to block off the unnatural flow of adrenalin. This simply takes away the urge for violent action against whatever petty little annoyance crops up during a period of depression. Fructose can work wonders for anyone subject to alternating fits of depression and anger.

Millions of people have chronic low blood sugar, or hypoglycemia, as part of their physical makeup. Millions more produce this condition by eating too many carbohydrates such as breads, potatoes, etc. which the body converts to sugar. Then there is candy, soft drinks, refined sugar used for sweetening, etc. Putting all this sugar into the system causes quick highs, followed by an equally quick low which lasts a lot longer than the original high. This is what people mean when they talk about low blood sugar. When your system can't handle sweets, you experience highs followed by miserable lows. This is bad enough on the mind and the emotions. But it is also a signal that you could be developing diabetes.

So knock off the excessive carbohydrates and drop refined sugars altogether.

Fructose gives you the same high without the resulting low. Adding fructose to the diet can mellow you out if you have the erratic symptoms of low blood sugar. You may find that you can deal logically and assertively without being the victim of feelings of anxiety and inner panic when confronted with a stressful situation. Nor will you be in danger of losing out to a surge of irrational fury and the desire to kick somebody's teeth in over a trivial matter or imagined threat or insult.

When I began taking fructose I followed a program. On the first two days I took two rounded teaspoonfuls of the granulated fructose dissolved in water every two hours. When I went to bed I had about five rounded teaspoonfuls dissolved in a glass of water next to me so that I could drink some when I woke up during the night.

Following this procedure saturates your system with fructose and your adrenal gland gets a total rest for two days. I found myself to be totally collected during the two days and I reacted to all situations intellectually rather than emotionally. The "flight or fight" responses were greatly dulled.

On the third day I began taking a level teaspoonful of fructose three times a day and that's what I take now, along with a greatly reduced dosage of niacin.

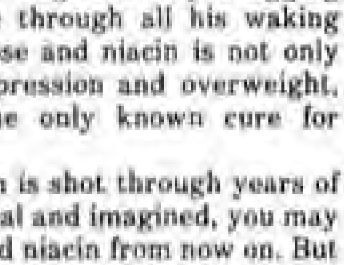
There's nothing as good as fructose for killing the urge for soft drinks or sugar. It won't make you fat. In fact, if you have a weight problem, fructose and niacin will give you a natural lift which brings with it energy you didn't know you had. You'll burn off that extra weight just in the course of your daily activities. Fructose is widely prescribed for overweight types. In some European clinics, fructose is even prescribed for diabetics.

Between niacin and fructose, I now find that I'm pretty together and I seldom have the urge for sweets, or even alcohol, by the way. Alcohol is also converted into sugar by the body. A depressed type drinks and soon his blood sugar drops and he's terribly depressed. The only way he knows to get back up again is to take another drink, and on and on. Niacin and fructose takes away the depression so he simply loses the urge to keep chugging down the booze through all his waking hours. So fructose and niacin is not only the cure for depression and overweight, but it's also the only known cure for alcoholism.

If your system is shot through years of troubles, both real and imagined, you may need fructose and niacin from now on. But both substances are relatively cheap, very easy to get and can be stored indefinitely. Considering what might lie ahead; mounting tensions, lack of medicines and general chaos, a lifetime supply of fructose and niacin could keep you reasonably collected through most of the chaos to come. These two items could be the cheapest and most important elements in your survival program.

A Simple Wire Stretcher

A novel arrangement, that is simply installed on any wire line to facilitate lowering or raising, or to maintain a uniform tension, is shown in the drawing. It is made from a bent bar of round iron.



Such a device is being used, in one instance, to keep wire clotheslines taut, so that no props or other supports are necessary. The wire is led through a hole in the post and fastened through a hole drilled in the bent bar. Turning of the bar crank winds the wire around it and tightens the line. The crank is held in place and prevented from unwinding by a loose loop, or link, which is slipped over its end.

How to Deactivate a Time-Bomb of Stress, Tension and Anxiety

by Cyrus Dickenson

Do you hear a strange ticking? Not a loud ticking. Actually it might be more of a vibration, and one that is somehow connected to your body and heart. That's it, your heart pounding! Has someone somehow wired a bomb to your heart? No, of course not, but it may very well feel like it if you are tense, full of anxiety, and under the stress well known to Survivors.

Where does stress, tension, and anxiety come from? Well, they can come from practically anywhere. But that question could easily be one of the most important you ever ask yourself. Actually, tension and anxiety are the result of stress that gets out of hand. This can be the result of the stress being (1) overwhelming (ie. ten men against one), (2) too many stresses at once (ie. fired from job, bills piling up, a bad cold, wife leaves you, or she comes home, etc.), (3) not knowing what the stress or stresses are or where they are coming from, or (4) unchanging, unending stress, including boredom. Then, stress can turn to anxiety and tension because the mind and body become exhausted with no relief, no rest, relaxation, or variation.

If we are to deactivate tension and anxiety we must identify the stress or stresses and deactivate we must or fail to survive. When anxiety reaches high levels for periods lasting days, weeks, or months, our body and mind begin to fail. Ulcers, heart attacks, heart pounding, rapid breathing, ridiculous fears, poor or unpredictble mental function, as well as a host of other troubles besiege our system. In short, we become physical and mental wrecks hardly worth saving.

Why would it be hard to detect stress when it's obviously all around us? Well, for the very reason that most people are looking all around themselves and usually fail to look within. Now I don't mean within one's head, but within his body chemistry. Often others try to convince us that there is something wrong with our minds, but we are foolish if we accept this as the cause or source of stress.

People whose body systems are in good balance don't have anxiety attacks, (I repeat, do not have anxiety attacks), are rarely tense, and enjoy a stressful situation, as it becomes a challenge to deal with and overcome, or reduce the stressful situation. So, if you are having a rough time coping, don't make the mistake of blaming all your problems on other people, places or things, or your mind. They are stress contributors but do not by themselves cause anxiety attacks. Only when your body is out of balance can other people and situations contribute to your anxiety attacks and tension.

One of the best clues that the disturbing stress is coming from within the body chemistry is if the person tries to self medicate with such things as alcohol, cigarettes(chain smoking), drugs, or lots of sweet, gooey candies, pastries, pies, cakes, cokes, or huge amounts of white bread and other starchy foods. This is an attempt to reduce stress by raising the low level of sugar in the blood stream. This helps momentarily, only to make things much worse shortly thereafter.

Anxiety is our bodies' response to unyielding stress. Anxiety can be felt by a pounding heart, rapid breathing, headaches, fearfullness of people, places, or things that don't usually scare us, or just a feeling of uneasiness. Anxiety is real. We never have to guess if we are anxious or not. Stress, also, is real in every case and is the cause of anxiety. In order to get rid of anxiety we must find the true source of the stress. This is our toughest and most important task.

There are two places to look for that disturbing stress. One is "out there" stress. The other is "internal" stress. The "out there" stress I will leave to you Survivalists to deal with. I am a Survivalist also, but my specialty is with "internal stress." I am convinced that one must check out the possibilities of internal stress before exploring for "out there" stress because an out-of-whack metabolism or body chemistry can fool us into seeing other people or situations as the cause of our anxiety attacks. When this happens we waste ourselves defending against the wrong target while the actual source of our discomfort continues to tear our system down. We could bomb and terrorize all the idiot's or organizations we don't approve of from now till doomsday and would never be satisfied till we get rid of the stress that actually is causing the uneasiness.

What if we determine that an imbalance or internal stress is caused by our eating, smoking, drinking, or other habits? In other words, if we have located a possible source of stress on our body metabolism, how do we get rid of it?

Many people do not want to hear the answer to this, but it can be extremely rewarding. The answer is DIET. Diet can reduce or eliminate anxiety attacks and tension, depending on how strictly the diet is kept. Usually when people hear this they cringe. To have to give up "habits" sends one into a quiet panic. It hits right in the gut. But don't take the hard way out of this by saying "Baloney that's the stupidest thing I've ever hear of!" Believe me, the easy way is to think about this through your own common sense after you carefully listen to a plan to eliminate anxiety attacks. There is no justified reason to panic. The thing you subconsciously fear the most will not happen. That fear is that you will have to give up your habit (like sugar and coffee for example) and you will feel even worse than you already do. Right?

As you read on, a plan will be spelled out to you where you can give up your habits while replacing them with specific foods that will not only avoid serious withdrawal, but will leave your body in a state of balance and feeling better physically and mentally than you can remember or even imagine. This is no exaggeration but like anything else one must have a personal experience before fully appreciating it.

Here's how it works. All food and drug habits (or cravings) are caused by LOW BLOOD SUGAR. When our blood sugar is low our body signals us to eat. The first signal is hunger sensations. If we ignore this then our body tells us in other ways like irritability, tension, aggressiveness, fatigue, light headedness, dizziness, cold clammy and sweaty skin, nervousness, or fear, and when mixed with other stresses that we are dealing with in our life, anxiety attacks will result.

Hunger is triggered from a drop in the level of sugar in the blood stream and not by how much food is in the stomach. The proof of this is that people are fed sugar and other nutrients through a vein, sometimes for months, without ever feeling hungry. This is why many people feel hungry or want to chain smoke, or drink etc., even if they are full. Their blood sugar level is still low. What goes in their mouth only satisfies momentarily or for an hour or so and then they feel even worse than before.

What makes some people crave certain foods, drinks, or other drugs, and not other people? The answer is faulty sugar metabolism. Some people are born with, and others develop, imbalances in the body chemistry. For example, a special part of the pancreas, called the isles of Langerhans, can be too sensitive to sugar. This part of the pancreas makes insulin (which the diabetic doesn't have enough of). Insulin normally keeps levels of sugar from being too high. When too much insulin enters the blood stream the supply of sugar drops. Then we feel crummy. So we eat, drink, smoke, or take drugs which all, in one way or another, briefly raises the blood sugar and then causes an even lower level to follow for those with the imbalance. The quick rise makes us feel good, then the drop makes us feel worse.

Are you starting to see the dilemma here? The harder the guy tries to get his badly needed energy up, the worse his whole life gets. His energy is either too low or it's going up and down like a yoyo. And when the blood sugar is low the first organ to be affected is the brain, which uses a piggish 25% share of all the body's energy supply.

To make things worse, when the pancreas constantly keeps the blood sugar down, other body defenses try to help out and make things worse. The adrenal glands, which are normally used only for emergency energy, release their many hormones, which make us want to run or fight for our life. This is confusing to others as well as ourselves. Then when we find ourselves in a real need to defend or escape, our adrenal glands are too exhausted to do us any good. Did you ever rip the phone off the wall during a domestic squabble? Or, scream and rant and rave over nothing? This can happen and does when the adrenals are doing their thing at the wrong time. This kind of stress we can do without. We try to avoid low blood sugar by eating or taking things that give us a lift. This plan backfires for those whose glands overreact. The reward is more low blood sugar. This, of course, lowers our chances of survival out there in the rat race of life.

This lengthy explanation is necessary before sense can be made out of what to do about it. There are three basic foods: proteins, fats and carbohydrates. We need all of them to be healthy. To deactivate the time-bomb of anxiety we must understand carbohydrates. Simply put, they are sugars and starches and would include fruits, vegetables, grains, and especially table sugar and honey, white bread and white rice. Common sugar, white bread, white rice, and alcohol are the most deadly time-bombs because they are wired directly to a hyperactive pancreas.

In short, we must stay away from the quick energy sources we need so badly. So, we must replace these explosives with carbohydrates (sugars and starches) that work more slowly. This includes whole grain breads and pastas, brown rice, beans, lentils, seeds, nuts which also have sufficient protein components which slow the reaction in our bodies. To this we can include the high protein groups of meat, fish, fowl, and dairy products. A normal amount of fat will be obtained in these high protein foods even without eating the fatty parts of the meat.

What I have just described is commonly called a high protein, low carbohydrate diet and at the end of this article will be a book list for you to refer to as this article is limited to describing the stress factors causing tension and anxiety attacks. These inexpensive pocket books usually refer to low blood sugar as hypoglycemia. I urge anyone who suspects they have problems with low blood sugar to read these books, which can be found in health food stores as well as other book stores and libraries.

Basically, the diet stays away from rapidly absorbed or refined carbohydrates and relies on more slowly absorbed carbohydrates and especially proteins which are not normally used by the body for energy. Rather, they provide material for tissue building and repairing as well as nerve functions. This diet teaches you to think protein instead of sweets, starches, or alcohols when you need an energy lift. This is an excellent diet. But one problem is that it takes the protein awhile to break down in the body and eventually be available as sugar or an energy source. Once the energy arrives however, it lasts for several hours. So if one eats small to moderate amounts of protein several times a day he can usually avoid that yoyo existance.

Within the last few months an exciting new addition has been added to this diet which quickly curbs one's desire to take addicting foods, alcohols, and other drugs. It is FRUCTOSE, also called levulose or fruit sugar. This must never be confused with other sugars which are strictly forbidden. Fructose has been separated from other sugar in a chemical process in Europe and is now marketed in the U.S. The beauty of this sugar is that it (1) does not stimulate the isles of Langerhans to produce insulin, (2) it gives quick energy to the brain and body. It also has the same amount of calories as table sugar. Synthetic or artificial sugars only trick you into thinking energy is soon to come. It won't. Fructose will give you the energy you need without activating that time-bomb of tension and anxiety attack. Fructose will not helpif taken without the special diet because the other sugars and starches will still trigger the low blood sugar. Fructose looks and tastes about the same as table sugar and is slightly sweeter. It can be purchased in health food stores and through mail order. It is expensive but easily worth trying. Prices can range from four dollars a pound to as low as $1.30 per pound which I found in a Co-op store. Tablets are available for a ready supply away from your kitchen. Refer to the booklist to follow for more details and technical information on fructose.

Good luck on your new diet and the new life to follow.

Abrahamson, E.M. and Pezet, A.W., BODY, MIND, AND SUGAR. New York: Pyramid Publications, 1971.

Cleave, T.L., THE SACCHARINE DISEASE. New Canaan, Conn. : Keats Publishing, Inc.

Martin, C.G., LOW BLOOD SUGAR (HIDDEN MENACE OF HYPOGLYCEMIA)

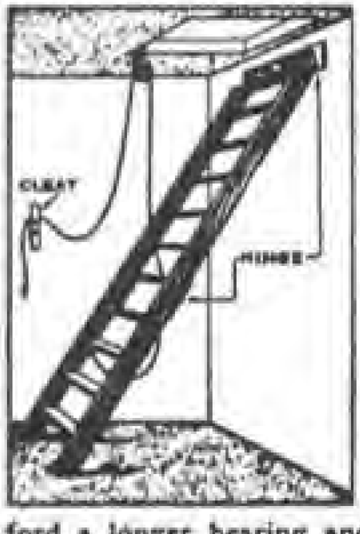
Fredericks, C. and Goodman H., LOW BLOOD SUGAR AND YOU.

Palm, J., DIET AWAY YOUR STRESS, TENSION, & ANXIETY (The Fructose Diet Book). Garden City, New York: Doubleday & Company, Inc., 1976.

Yudkin, John. SWEET AND DANGEROUS. New York: Peter H. Wyden, 1972.

Folding Attic Steps

The steps shown in the drawing are particularly serviceable when the opening to the attic is located in a closet, or small room, where there is insufficient space for swinging a full-length ladder to the ceiling. The upper end of the steps, or ladder, is attached to the wall with hinges, as indicated. The side rails are sawed in two near the middle, the cut being made in a diagonal direction to afford a longer bearing and to bring less strain upon the strap hinges by which the sections are joined. By means of a rope and pulley, the lower section is folded inward against the upper section when the steps are drawn up. The steps are held in the raised position by taking several turns of the rope around a cleat on the wall.



Insects Killed with Glue

From Popular Mechanics 1931

A new method of exterminating insects on evergreen trees about your home is suggested by experiments at the State University of Ohio, where it was found that a solution of glue and water was an excellent insecticide. The solution is made by mixing glue, 1 lb., and water, 5 gal. It is sprayed on the trees and holds the insects in the same manner as flies on sticky paper, without injuring the trees. Besides killing the insects, it also prevents their eggs from hatching.

SURVIVING WITH MENTAL PROBLEMS

By Bill Abreu

Some recently proven theories held by doctors and nutritionalists may shed some truth on the old saying, "you are what you eat." In fact, from what tests and studies have shown, it is possible for certain foods (or lack of) to be the cause of an irritable or temperamental disposition (not to mention depression, fatigue, and a variety of many other mental problems).

Food allergies, though mostly well known for causing physical problems, such as cramps or hives, can frequently cause anti-social behavior in many individuals. These allergies differ from inhalation or skin allergies in that their reactions can be delayed for a period of hours or even days. When this situation occurs the food allergy can then be linked to addiction, on the basis that the only way in which the person can temporarily relieve the allergy is to eat more of the same offending food.

One large contributor to food allergens is food additives and pollutants which can be found in cured meats (i.e. hotdogs, ham, etc.) to act as a preservative. These additives, while giving the meat an attractive red color and stopping the growth of bacteria, can cause reaction such as depression, weariness, hyper-activity, or tension.

But other foods, apart from additives, can also cause reactions in certain people. To find a person's allergen a doctor has the patient fast for four to six days. At the end of that period the patient is fed the suspected food and if a change in behavior occurs (though it may be subtle or drastic) the cause can then be diagnosed.

More specifically, salicylate, a chemical found in food coloring the flavoring agents, is a known allergen linked to hyperactivity. This chemical causes a swelling in the lining of the brain (which is then called cerebral swelling or allergies), hence the anti-social behavior. In experiments with hyperactive patients it is shown that when salicylate is eliminated from their diets, the majority of patients calm down significantly.

The list of foods containing salicylate is quite unfortunate, being that they are the foods which many people are most fond of: candy, cured meats, soda, and strangely enough even some children's chewable vitamins (it's amusing to think that Flintstone's Vitamins can turn a child into a tyrannosaurus rex—very loosely speaking of course).

Salicylic acids can be found largely in aspirin. This is very significant when one takes into account that 27 million pounds of aspirin is consumed yearly (enough to treat 17 billion headaches). Even worse is the fact that tests have proven that aspirin has no more pain-killing effect than does caffeine. Furthermore, it is believed that aspirin, among other drugs such as insulin, would now have a difficult time being passed onto the market if they had to meet the strict standards of today. Salicylic acid, aside from causing cerebral swellings, can also harm the mucosal cells which line the inside of the stomach, unless the tablets are buffered or if food has been eaten prior to the drug's consumption.

(If aspirin must be bought, it is best to purchase the least expensive brand, because all aspirin must pass the same U.S.P. requirements.)

As of now you might be looking back through your memory, trying to find an instance where you ate an aspirin or hotdog and suddenly were transformed into a raving madman. The truth is that the reactions are not that drastic nor that immediate in most people. The situation would more likely be that the person is easily offended or quick-tempered (which might be alien to his normal personality) due to certain foods he has been eating for some time. Though the change to anti-social behavior is gradual, the process to revert back to a more calm and normal disposition can sometimes be remarkably fast. There have been cases where mothers have noticed prominent changes in their child's behavior within a very short time, all for the better. (And what about Paranoid George's ten minute cure for his problems as described in Vol. 2 of THE SURVIVOR.)

To find your allergen, if you suspect that something is making you tense or irritable, can be fairly simple. First, the most likely suspected food (or perhaps a whole food family) is eliminated from your diet for three days. If no change in attitude occurs then you move on to eliminate the second suspected food. Finally when a change does occur you simply check to see what food has most recently been eliminated, and obviously drop that food from your diet completely.

To treat mental problems without using standard methods, doctors will sometimes use the orthomolecular or the megavitamin therapy. There is not too much difference between the two, except that more vitamins are consumed by the patient with the megavitamin therapy. Both of these treatments are much safer than the usual methods continuously used and in many cases they have even proved to be better. For one thing, no foreign elements, such as drugs and tranquilizers, are introduced into the system, and those excess vitamins which the body does not use are simply gotten rid of, being that they are water soluble.

However, it is not necessary to have a doctor lay out a specific diet to fit your personal needs, when it is possible for the same results to be accomplished by following a few simple and common sense methods.

The first thing to do is to have a healthy diet. This is not say that you should immediately run out to your nearest health food store and buy sea weed, bird seed, or what have you. A well rounded diet of foods containing the minimum requirement level can be found and prove helpful to one's mind as well as one's health.

It is unwise to drop sugar of all forms from your diet as some might instantly assume (this would be difficult to do anyway, since sugar can be found in so many foods). A drop in sugar content can cause depression, grouchiness, or fatigue. Also, too much sugar can over-stimulate the pancreas into pumping large quantities of insulin into the bloodstream to handle all the sugar. With all this insulin in the system the sugar's original purpose is thereby defeated. As mentioned in THE SURVIVOR, fructose is an excellent substitute for over-refined sugar which is contained in many sweets.

Minerals are also an important part of every diet and can be just as beneficial to your mental health. In a well-diversified diet, a sufficient supply of minerals will be found in milk, milk products, table salt, meats. The most abundant and important of minerals is calcium which is essential to every living cell. When a calcium deficiency is present the effects are much like those of a sugar or niacin deficiency. However, it can easily be corrected by eating more calcium-filled foods such as green vegetables, lean meat, and milk, or by simply taking calcium tablets which can be bought, non-prescription, at any drugstore. Calcium tablets are good also for relieving headaches (better and safer than aspirin), alleviating pain (two or three can be taken before dentist visits), or for curing insomnia.

Vitamin C can also be important for your survival diet because it detoxifies the effects of allergens which might somehow work their way into your system, despite precautions taken to avoid them. Often, the trouble-causing allergen can be found in some foods you might be unaware of or have overlooked.

Vitamin B6 is used largely in megavitamin therapy for the treatment of allergies to food additives, wherein the patient is denied offending foods containing additives and given large doses of vitamin B6 along with minerals and other vitamins. It has been shown that hospital patients lacking vitamin B6 tend to develop depression, nausea, and vomiting. Once these patients are given dosages of vitamin B6 they quickly change back to normal with no side-effects.

Vitamin B1 (thiamine) aids in producing energy. However, this is not to say that with consumption of three or four of these vitamins you will suddenly be able to do heavy work or run miles without tiring. Vitamin B1 when taken with a well rounded diet of other vitamins and foods can be helpful. People without vitamins B1 are fatigued, and constantly exhausted.

These vitamins, if taken properly and incorporated with a survival diet, can be favorable to one's physical and mental well-being. When the situation arises where getting along with your fellow survivalists is one of the main objectives in surviving after the crash, it will be best to have a complaisant attitude to keep peace in a group. Eating healthy foods and proper vitamins can be the key to survival in such a situation.

But this situation changes dramatically when the deficiency is corrected. By way of foods, vitamin B1 is included in bread, cereals, and unrefined foods such as peanut butter.

Vitamin B3 is simply niacin, a vitamin which is sometimes referred to as the "morale vitamin," and is discussed extensively also in Volume 2, of THE SURVIVOR.

In that calcium is helpful in relieving pain and headaches, vitamin D aids in promoting the absorption of calcium. Vitamin D can be obtained from homogenized milk and when taken in capsule form, should be consumed after a meal which might contain fat. Because vitamin D is used very little, it may sometimes be sold by prescription.

PICTURE FRAME AND TRIANGLE CLAMP

From Popular Mechanics 1915

A picture frame or triangle is quite difficult to hold together when fitting the corners. It is still more difficult to hold them together while the glue dries. The clamp illustrated will be found quite satisfactory in solving this problem, and at the same time is very simple to construct and easy to manipulate. The material list for making the clamps and corner blocks is as follows:

Picture frame clamp:
4 pieces, 1⅜ by 1⅜ by 15 in.
2 pieces, 1⅜ by 1⅜ by 5 in.
Triangle clamp:
3 pieces, 1⅜ by 1⅜ by 10 in.
1 piece, 1⅜ by 1⅜ by 4 in.
Corner blocks:
4 pieces, ⅞ by 3½ by 3½ in.
8 pieces, ⅜ by 1 by 2 in.
The pieces mentioned are of oak, S-4-S.
1 piece ⅜-in. maple for dowels
Hardware:
10 bolts, ¼ by 2 in.
4 bolts, ¼ by 3 in.
2 bolts, ¼ by 6 in.

The picture-frame clamp consists of the four arms A, B, C and D, Fig. 1. A ¼-in. hole is bored in one end of each piece, ½ in. from the end. A series of ⅜-in. holes, 1 in. apart, are bored along the center in each piece. The two short pieces, E and F, have two ¼-in. holes bored in their centers, ½ in. from each end. These pieces are bolted to the four arms with ¼-in. bolts as shown in the sketch. A ⅜-in. hole is bored in the middle of each piece E and F for one of the 6-in. bolts K.

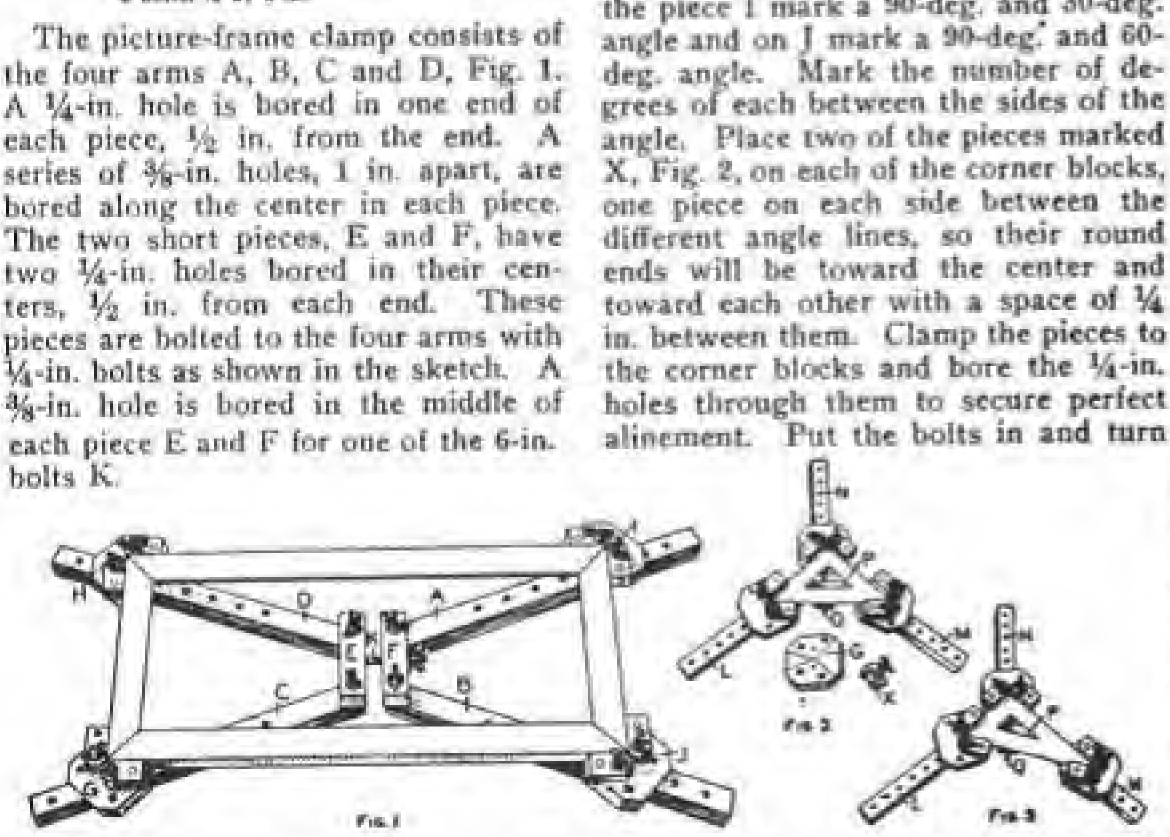
The four corner blocks G, H, I and J, Fig. 1, have a ⅜-in. hole bored in the center of each and a dowel glued into it with the end projecting 1¼ in. on the under side and level with the surface on the upper side. Each of the corner blocks is fitted with two pieces like X, Fig. 2. Each of these pieces has one end round or a semicircle, and in its center a ¼-in. hole is bored. The other end has a ⅜-in. hole bored ½ in. from the end.

After making the small pieces, take the four corner blocks G, H, I and J and draw a line on the upper side in the center, with the grain of the wood, and mark the angles as follows, so that one-half the angle will be on each side of the centerline: On one end of the pieces G and H mark a 90-deg. angle, on the other end a 45-deg. angle, on the piece I mark a 90-deg. and 30-deg. angle and on J mark a 90-deg. and 60-deg. angle. Mark the number of degrees of each between the sides of the angle. Place two of the pieces marked X, Fig. 2, on each of the corner blocks, one piece on each side between the different angle lines, so their round ends will be toward the center and toward each other with a space of ¼ in. between them. Clamp the pieces to the corner blocks and bore the ¼-in. holes through them to secure perfect alinement. Put the bolts in and turn the pieces first to one angle and then the other, and while in the respective positions, bore the ⅜-in. holes ⅜ in. deep in the corner blocks. Glue a dowel in each ⅜-in. hole of the small pieces, allowing it to project ¼ in. on the under side so it will fit in the ⅜-in. hole in the corner block. Be sure to countersink the holes for the heads of the bolts. All bolts should be fitted with wing nuts. All that is necessary to change from one angle to another is to loosen the nuts and swing the small pieces around so the dowel pins will drop into the other holes, then tighten the nuts.

The triangle clamp is made in the same manner as the picture-frame clamp, except that the arms L and M, Figs. 2 and 3, are half-lapped into the crosspiece P. The bolt O is ¾ in. and the head is cut off. Drill a ⅛-in. hole in the bolt, ¼ in. from the end, and bore a ⅜-in. hole in the end of the arm N. Insert the headless bolt O in this hole and drive a nail through the side of the arm N, so it will pass through the hole drilled in the bolt. This keys the bolt in the end of the arm N.

To clamp a picture frame, set the corner blocks G, H, I and J to the 90-deg. angles and adjust them on the arms A, B, C and D to accommodate the size frame to be made, as shown in Fig. 1. Tighten the thumbnut on the bolt K, and this will draw all four corners together with the same pressure. The corners can then be examined to see if they fit properly. If they do not, saw in the joints with a backsaw until they do fit.

The triangles are clamped in the same way. The corner blocks are set to take the proper angles. The ends of the bolts should be slightly burred over so that the thumbnuts cannot be turned off.—



The Corner Blocks on Both Picture Frame and Triangle Clamps are so Constructed That They Hold the Molding together While Fitting the Corners and also Hold Them Securely While the Glue is Hardening

SURVIVAL OF THE FITTEST

by Tom Murphy

It all began on a seemingly normal day. At least as normal as the days had been being, each day's news being filled with near panic events, droughts, floods, many food crop failures, a new oil boycott, sharp rise in inflation, shortage of manufactured goods, massive power failures, increased terrorist activities, crimes of violence. People were scared and rightly so. It seemed that everything was building up to a peak, you could feel the tension in the air.

I was not too worried since I had made advance preparations some time ago to ensure the security and safety of my family. We had bought a small farm well off the beaten path, 6 acres but quite remote, the closest neighbor being a half-mile away. We had been established over 3 years, building up a nice sized garden, a good well, and had lots of trees for plenty of firewood. My wife Susan is a very prudent person and she believed as I do in being prepared for any occurrance.

Since we're so far out in the country, we're more subject to power failures, so I had acquired an A.C. generator for emergency use. The deep well has an electric pump and lots of fresh water is important, not only for drinking and washing but for sanitation too. The generator is housed in a concrete building together with drums of gasoline, lubricants, tools, and other survival supplies, as well as a small chemical lab. Drums are not ideal for the storage of gasoline as they tend to rust, however they will last for many years. Gasoline will keep almost indefinitely if kept in a closed system. It's the exposure to air that causes it to deteriorate. I had on hand 8 drums for a total of 440 gallons plus 10 in the generator or 450 gallons. With careful use it would last for years or at least hopefully till things had stabilized. In that period of time, we would have had a dug well completed as well as expanded food supplies. So with power for the well, for communications equipment, deepfreeze, etc., we should be o.k. The generator has a good muffler system and is in a sound concrete shelter, it makes very little noise, which is very desireable. I didn't want to call attention to my little stronghold when the chaos occurs.

Over a period of years we had accumulated a good assortment of survival supplies—all with the idea in mind of not being able to get it if we didn't have it already. Travel would be very dangerous during the panic, so we decided to do without a lot of luxuries so we could be prepared. It sure is better to have something and not need it, than to need it and not have it. Some items are critical to life support, such as medical.

I left work early in the afternoon, listening to the truck radio—lots of bulletins coming on from the big cities, demonstrations, blackouts, some looting—the military had been placed on alert, and some National Guard units called out to help maintain law and order. I was going to stop by the grocery store, but the parking lot was jammed with cars and there was a large crowd in front of the store. Unbelievable—right here in a small southern town—people get scared and it's like a wildfire. I turned the truck around and headed for the house—looks like the time to put plan A into effect.

Susan met me at the door, with a worried look on her face—"Tom, I'm afraid it's starting to happen." I told her that I believed that also, and to start plan A—which is to notify the people that were to come to our retreat for safety and mutual defense—Susans' parents, my parents, and John and his family (Susan's brother), who lived 70 miles away. After quick phone calls to all, we began our own emergency preparations, which were not extensive as we had been on "alert" for weeks. I looked with satisfaction at the large store of foodstuffs, bedding, clothing, guns, ammo, tools, books, and agricultural supplies. Wished it could have been more but we did the best we could in the time we had since we became aware of the situation. Commercial power was still working, so we began filling the water jugs. I cut off the butane to the hot water heater to conserve, but left it on for the cookstove. I checked the gauge, about 2/3 full, 250 gallon tank. I had in storage four 50 gallon tanks, so cooking should be no problem for a good while.

Sure glad it's summertime, won't have to worry about burning wood with resultant smoke for at least four months, again so as to not call unwanted attention. With the new woodburning heater, there's not much smoke anyway compared to our old open fireplace. Checked the camping stove, two burner, 16 gallons of gas, Kerosene, 10 gallons, with two lamps, one lantern. I broke out the shovels and pickaxes; sure going to be a lot of digging when help gets here—defense positions, mantraps, punji holes, booby traps and warning devices. I had long ago made up duty rosters and plans for fortifying the homestead.

Considering the amount of work involved, I had thought about doing a lot of it as I went along. However, I didn't want to call undue attention to my future plans. All I needed was to have company drop in and see the field fortifications and thus start asking questions. This occurred once when someone dropped by my communications shack and saw a few cases of canned goods and said, "Boy, I'll know where to come to when I get hungry." There's no way to explain to this type of person—sure hope he doesn't try to show up. Hate to be hard-hearted but if we share with everyone that comes along, I would be denying my family to benefit someone else who screwed off and spent their money on color TVs and boats while we did without to preserve ourselves. Everyone had the same chance to prepare and if they didn't see the need, then maybe they were too dumb to survive on their own. Nature weeds out the inferior.

I thought about my half-brother whose idea was to head for the woods, with what he could carry on his back. I left him a standing invitation to come be with us when he got tired of tramping around. I believe that he'll make it o.k. For many months he has been backpacking into the woods on the weekend, lots of experience gained, as well as getting into shape—well equipped, compass, topographical maps, etc. He knows well enough to make his presence known before he tries to come in. The old wild west idea—shoot first and ask questions later—hard words but it's gonna be a hard life.

He had one thought that sure seems to make sense. Some talk about "Bugging" out and including books on how to survive; he feels that experience is what counts, if you have to have constant reference to a book, your chances are reduced. I have an extensive library, but I have lots of things I need to grab if we have to "bug" out. A static location is best from the standpoint of defense, with fortifications and enough people to defend it. It can be overrun, but damn hard to do, the attackers have to pay the price.

Someone's coming! It's our parents in pickup trucks with a big load on the back of each—foodstuffs, bedding, weapons, etc., welcomed manpower and goods. Sure hope John will get here before dark. News getting worse, everything coming unglued. Had a quick meeting while I outlined the course of action—sent two of my sons out on guard duty, heavily armed, with C.B. walki-talkies for communications. I had an Army surplus field telephone system which would be used on occasions when we didn't want to transmit over the air, and "they" have radios too. A couple of folks started stringing wire, one using a garden spade to make an opening in the ground while the other put the wire in the slit made by the spade. Other wires were put down and run to stakes around the perimeter of the land.

The chain of command had been discussed on previous occasions. I pointed out that this was my house and my land, and most of the supplies were mine—thus we don't vote on issues. I listen to advice and counsel, but I make the decisions—sure stops a lot of problems before they get started. It was hard for the parents to accept this, but they did. After all, they could have prepared and invited my family and me over. Then of course, I would do as I was told. They didn't, I did. So that's the way it is.

Getting darker, John still hasn't arrived from the city—the ladies are in the process of supper, early to bed for all but guards, no lights at night. Well, no lights at all at least from commercial sources, power just failed, radio on batteries, all hell has broken loose. People going nuts, the whole system has ground to a halt—Overseas looks the same. The economies of too many countries are tied up too much with that of others, one affects the other.

Everyone into bed, I cut off the radio, get my rifle, 45 automatic, and flashlight and go down to the driveway entrance. Skip is at the curve of the driveway, covering the entrance. He's seen several cars go by, but all is quiet. Gary has the dog with him, we hear a dog barking in the distance, our's has been trained to not bark, but to give indication of "something out there." Sure dark tonight, overcast. There's someone coming, gravel road, can hear a long ways. I went to the edge of the woods to take position at the side of the entrance, in a ditch. Two vehicles, a car and a truck, stop short of the entrance. "Hey Tom, it's John"—flashlight check, sure enough—mighty glad to see them.

Both the car and truck are loaded down with supplies. John said it was a good thing they lived on the edge of the city as he thought that they would not have made it if they had been further in. He said it sounded like the opening day of deer season. Lots of gunfire coming from the main section. There were a number of people out of gas on the roads leading out of the city, but just no way to help them.

Well, left Skip on guard duty and pulled the car and truck up to the house. Sure a lot of vehicles around now. Started to unload but decided to wait until morning in order to not show lights. Also decided to take gas tanks off most vehicles and close park them around the house for additional bullet proofing. Also had sandbags to be filled to put next to walls. Hard to get everyone settled down again, but soon quiet again—time goes fast—time for guard change—quick call on the C.B. to alert guards of change—(their walki-talkies have earphone jacks, which they are using, also squelched tight, with short antennas as we only need short range communications and they have some freedom of movement without being tied to telephone system. In the daytime with better visibility the telephone system will be used mainly.

I'm getting some shuteye, I go on guard duty at 3 AM. Quiet night, just the way we want it to be. Sun coming up, looks like a nice day, hot though. There sure is a lot of work to be done today. Had a quick breakfast—got enough water for several days—deep freeze should keep for 3. Listened to radio, National Emergency, President pleading for calm, law and order—gangs of looters going amuck, stealing and killing anyone in their path. Looks like we really need to be on the alert.

Went ahead and ran the A.C. generator, put freezer on lowest setting, ran well and filled and refilled all available containers. Sure glad I soundproofed the system as much as I did. Can hear it running only a short distance away. Ran it for two hours. It's a big job to get things organized, with as many people as we have (21), it takes a lot of food—the garden is in great shape, lots of stuff needs picking today. Betty (John's wife), is in charge of food, procurement and inventory. We are going to utilize the garden to the fullest extent possible and save the other food supplies for wintertime use. We have a large supply of jars and lids, so there should be lots of home canning this summer. The only workable way to get this done is to go back a long way—the women and children do their work, the men stand guard, hunt, and heavy work. This is the most workable system, no place for women's lib in a survival situation. Our forefathers survived and maybe that's why.

I've gotten the digging started, a system of defense positions first—then obstacles next to impede any assault. The only way to defend the house is to have a system of foxholes or fortified positions away from the house—if we tried to defend from the house about all it would take would be one attacker getting close enough to hurl one firebomb. By putting our main positions of defense away from the house, the women and children firing from the house gives a good second system. Also each fortified position has clear angles of fire so that if an attack came from only one direction, fire could be directed from all positions toward that direction. We have to stay on the alert and not be surprised.

I monitor the radio quite often, things are very bad indeed. The C.B. radio has occasional calls for help, no way. Things are starting to settle down into a routine, and that's not good. A routine leads to complacency which leads to carelessness. I changed the guard schedule up. Supplies are holding out real well, fuel consumption is low, mainly because the ladies prepare easy, quick to cook, stick to the rib type meals.

It's into the fifth week now, we saw some smoke east of us yesterday afternoon, and heard some faint shooting, must be three or four miles off, there's a small town in that area. Don't know, but it looks bad. Stepped up the watch, that means that everyone goes around armed—believe we are prepared. The defenses look good, but I suppose could be better, but then there are limits to what you can do. I have seen signs of activity from my neighbors—looks like they've holed up like us. Being in the country, all have a good start on survival. Lots of water, from dug wells, to creeks and ponds. Again we hear the sound of gunfire, closer this time. Plan B into action, carefully, homemade explosives are taken from cool storage underground to the stakes around the perimeter, wires attached, and the charges buried. This is extra manpower to defend against an assault force. Top alert—no outside activities, guards doubled.

I have dreaded it, and now my worst fears are realized. There are people coming down the road, armed, 16 in all. There's a sideroad or two off the road before my place, leading nowhere really, and some of the group is checking each road out. Their intentions are obvious. The word is given, War Footing, everything is ready, all positions are manned. I'm in the command fortification with the explosive control box, each charge on a separate switch, system armed. We are discovered by two, one goes back and through binoculars I see a discussion under way. The one is joined by another, they advance up the road. "That's far enough!" I shout. They stop. "What do you want?" I asked. "Oh," they said, "we are just looking for supplies. Do you have any extra?" "No, I replied, move on!" "Sure," and off they went.

More discussion, still from the road area. A couple run up behind a seemingly natural cover and open fire on the house—and from the house comes a pitiful reply of a couple of .22s from the ladies. We must deceive the attacker, so that all will commit themselves and can be destroyed. If we had committed ourselves at first, their tactics would have changed. As it was, they staged a mass assault, all at one time, which is just what we wanted. Hold your fire, hold it, let the ones in front go past the explosive charges, the ones behind are over the charges now—detonate—the explosives work very well, the ones in front are stunned, quickly fire and fire again. Nothing moves. A body count, the same as were observed coming down the road. Looks like we got them all. Guards out, still max alert. I checked the bodies, a real dirty looking bunch, one has a sack full of paper dollars. What a fool! All of their worries are over, except for one still alive, but not for long.

Things are peaceful once again, sure had a job with the burial detail. We salvaged everything before burial, including the paper money. Think I'll wallpaper my bedroom. There are very few radio stations on the air, communications have really broken down. Everything is disorganized and there's no telling when the situation will stabilize. We'll just stay on the alert and do the very best we can under the circumstances. No person could ask more.

I often think of all the misery that has occurred and will continue to occur. The old, the weak, the sick, the very young, the defenseless, all assaulted for the things they might have that would be desirable. Once the restraints of society are off, the dregs of the human race come creeping out of their holes, the worst side of man comes out. I am thankful we were prepared and I believe we will survive mainly because we became familiar with arts, crafts, survival information, first aid, chemical processes, firearms, etc., all add up to insure, as in nature, The Survival of the Fittest!

Five Shop Machines Fold into a Portable Box

By C. A. VAN DERVEER

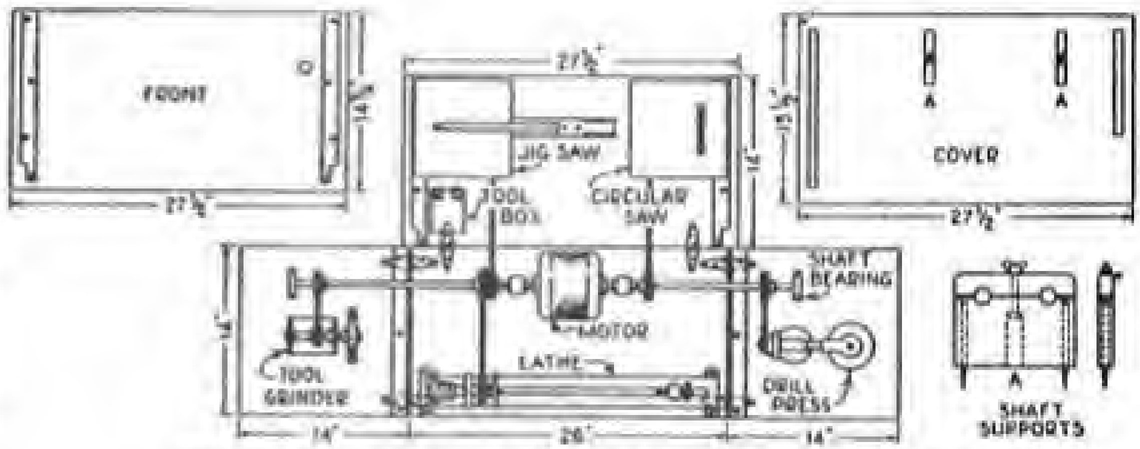
Popular Science 1936

A PORTABLE workshop containing a drill press, lathe, emery wheel, jig saw, and circular saw, which folds into a box the size of a tool chest and can be placed on the running board of an auto, may easily be devised by anyone who wishes to take his shop with him from place to place. It can be set up on a table wherever a 110-volt 60-cycle plug is available and is ready to operate within a few minutes.

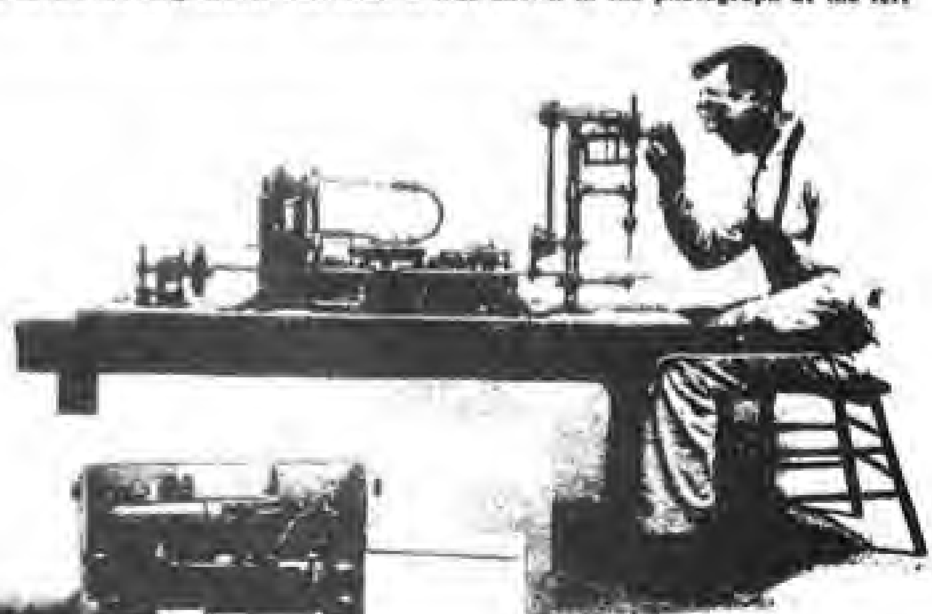
The photographs and drawing show the general layout. Ordinary ¾-in. boards are used throughout. Be careful that the various parts are perfectly square. It is necessary, of course, to put cleats on the boards to prevent splitting and warping; and these should be placed across the grain.

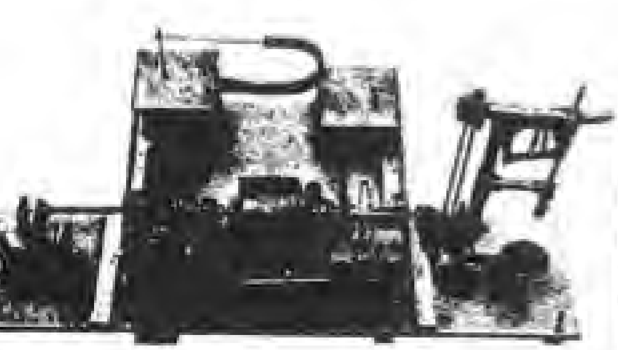
When the shop is to be moved, the shafts are uncoupled from the motor, removed from the bearings, and secured to the cover.

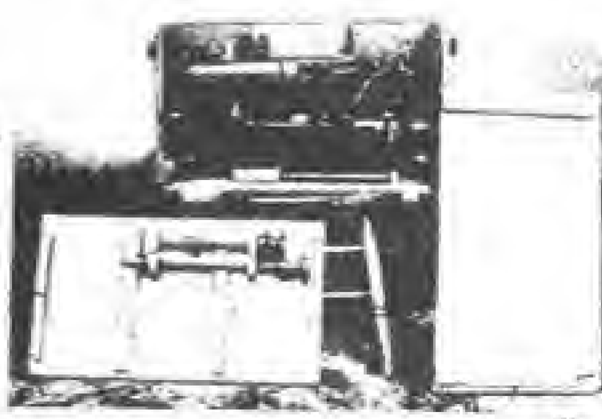
In most cases regular home workshop machines of the smaller sizes would be used, but the machines shown were built by the author from parts found in junk yards. The drill press, for example, was made of short pieces of pipe and pipe fittings, and a model-T Ford piston rod was used to form the adjustable table bracket. The drill press and lathe have four-speed pulleys. A motor with a double-ended shaft was purchased from a mail-order house.



The front and top or cover of the box are removed and the remaining parts are opened out flat by means of hinges so that the machines and motor may be set up as in the drawing above. The outfit is also shown in the photograph at the left







The machines set up for use and, left, how they are packed in the box. The shafts are uncoupled and clamped to the lid. The outfit includes a small lathe, jig saw, circular saw, grinding wheel, and drill press

CHICKEN OF THE SWAMP AND SUBSTITUTE SHRIMP

By Jim and Stephanie Watters

I've always liked frog legs, but I'd never thought much about finding them in the city until the slump. While driving home late one rainy night I kept seeing frogs of all sizes on the highway. When some nice bullfrogs started jumping in front of my van, I couldn't imagine where they had come from, but I couldn't stand to see all that good chow just hop away. I got on some streets where the traffic was slower, and just began stopping and picking them up. The big fellows would sit there starting into my headlights and I'd slip around behind them and grab them.

That really started me looking for frogs in town. I located all the ditches and ponds in the city limits. Some of them looked more like garbage cans than I would like, but when I went back late that night, I could see plenty of red eyes among the beer bottles. In one little pond behind our church parking lot, I counted over twenty pairs of eyes and took home twenty four pairs of legs. That little depression doesn't even have water in it all the time, but it had plenty of frogs. The big ditches near the local high school and another church parking lot has kept us in frog legs for the past two summers. The boat-launching pads near the park are another good place. And the people at the restaurant within easy walking distance of our house don't know that the ditch behind their place holds better food than they sell. There are plenty of other good places, but I mentioned all these just to start you thinking of how many places you probably drive by everyday and never notice.

Let's say you've thought of a few places and you're ready to try your luck. How do you intend to catch the frogs? (And incidentally, they don't have to be real bull-frogs. Just take any frog that you think is big enough to eat. Leopard frogs and green frogs make good eating, too.) You can catch frogs with a hook and line, shoot them with pistols, rifles, shotguns, air-rifles, or bow and arrow, or net them, or club them, or spear them. I prefer spearing, or gigging, as we call it down here. Gig heads should be a part of your survival gear, anyway. Go ahead and buy a couple or be a real survivalist and make some. For a handle, I've known some folks to get by with a broom handle, but I prefer an eight to twelve-foot bamboo handle because, with it I can reach all the way across a ditch. For a light, I have done all right with just a two-cell flashlight but you'll do better with a head-lamp—it leaves both hands free—or at least a six-volt lantern. Stick your little two-cell in your hip pocket for a spare, along with some recycled plastic bread bags to put your frogs legs in. Sometimes I carry a folding wire fish net to keep them in and cut the legs off at home. But if you're by yourself I'd recommend cutting off the legs and carrying them in bags. Cut them off at the hump where the legs join the back bone. You can eat the whole frog, as we have done, if you want to, but most of the meat in on the back legs.

Frogging is more fun and more productive with a friend. With one of you on either side of a ditch, you'll find a lot more frogs, because he can see them under the overhanging vegetation on your side and you can do the same for him. Also, a direct beam seems to hold the frogs better. Anyway, it's nice to have a buddy with you when you're scrounging around our cities at night. Frogs aren't the only things that come out at night, unfortunately.

Preparing frogs for the table is easy. Just slice the skin across the hump on their back, stick a finger under it and pull it off the legs like panty-hose. Cut through the leg bones at the hump and slit the belly back toward the legs. Cut off the feet, pull out the nerves that look like strings so he won't upset the wife by jumping around the pan, trim around the rear vent if you like, and toss him into a pot of water to soak a minute while I rest.

All right, it shouldn't take as long for you to do all that as it did for me to write it. I prefer to soak my game for a while before I cook it, and I always like to freeze my frog legs before cooking. Believe it or not, it makes them more tender. But neither the soaking nor freezing is really necessary. When you've washed off those beautiful frog legs—and even your hoity-toity mother-in-law will tell you how pretty they are—you may want to just toss them in the frying pan right away. That's easy enough. Just roll them in flour or corn-meal and fry them in deep fat, or just a little hot grease. Add a little salt and pepper and try them, and you'll see why I'm a confirmed frog freak.

Now, about those substitute shrimp I mentioned in the title: have you ever tried crayfish? We call them crawfish down here, but whatever you call them, if you like shrimp you'll like these little critters, too. Chances are you'll find them everywhere you find bullfrogs because the bullfrogs enjoy eating crawfish, too. Crawfish are easy to catch at night by hand or with a little minnow net, or if you find the really big ones, a forked stick. There are other ways to catch them faster and in greater quantity but you ought to be able to catch enough to make crayfish cocktails while you're spearing the main course.

When you get home, drop them alive into boiling water. They're ready to eat when they have turned bright red, but cook them up to 10 minutes if you're going to use them in cocktails. Most of the meat is in the tail which will be easier to shell if you take the crawdads out of the boiling water and put them immediately into cold water.

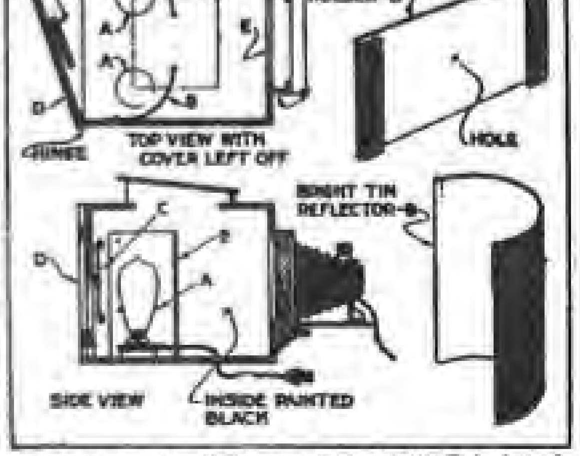
Well, there you have it—food good enough a gourmet or even your mother-in-law. You can begin now to learn important survival skills right in the city. There are many other good techniques you can learn to incorporate with these, if you'll just turn off the idiot box and get down to it. It's not enough to read how—you have to go do it yourself. Someday the simple survival skills you can learn now may help keep your family alive in hard times. But if it never comes to that, you can enjoy a sense of self-reliance while you chow down on that delicious free food.

Improvised Post-Card Projector and Enlarging Camera

From Popular Mech. 1919

AN outfit which may be used for either projecting picture post cards or enlarging photographic negatives was assembled as delineated in the illustration. An ordinary camera, which provides the lens and bellows, is required, in combination with a dark box which can be built in the home workshop. The method of construction is this:

Make a box about 8 in. square out of



An Ordinary Small Camera, Fitted with This Attachment, Becomes an Enlarging and Post-Card Projecting Camera

½-in. planed soft-wood stock. Nail the sides, but omit, for the present, the top and the bottom. The two openings thus left will be called the front and the back. Mount an 8 by 8 by ½-in. board, D, which constitutes a door, on the back with hinges and provide a hook to hold it shut. Cut a square hole, of the same size as that of the opening in the back of the camera which is to be used, in another 8 by 8-in. piece, E. This will constitute the front board. This front board is so cut that it fits in between the sides of the box instead of on the ends, as does the back. In the top, cut a square hole for ventilation. A hood is provided over this hole to prevent light being thrown forward.

When using the arrangement as a projector or magic lantern two 40-watt tungsten lamps, A, are required. Each lamp is mounted in a porcelain receptacle held on the floor with screws. A lamp cord, one end connecting the two lamps in multiple and the other fitted with an attachment plug, passes through a hole in the floor of the box. Form the two reflectors, B, of 8 by 7-in. bright tinned sheet-iron pieces, each having holes along one of its edges to admit of attachment. The reflectors are bent to a semicircular contour before mounting. The card holder is detailed at C. It is a piece of tinned sheet iron bent to the form shown so that it will hold a post card. A hole is drilled in its center for a screw pivot. It can then be fastened to the center of the back door and can be turned into position, for either horizontal or vertical pictures.

A washer is inserted on the screw between the holder and the door. The thickness of the camera body having been determined, a slide is fastened to the front board, as diagrammed, to support this body.

Before it can be used as a projector it must be adjusted to operate with the camera of the type and size available. The adjustment, which must be made in a darkened room, having on one of its walls a white screen on which the image will be projected, is effected thus: Remove the back from the camera and place the camera in the slide without extending the bellows. Open the shutter. Insert a card in the holder C. Light the tungsten lamps. Now move the front board, with the camera carried on it, back and forth within the box until the components are in focus, that is, until the most distinct image obtainable is reproduced on the screen. Then, illuminate the previously darkened room and nail the front board in

THE PROBABILITY OF NUCLEAR WAR

By Kurt Saxon Written in 1978

Although nuclear war becomes more pointless and suicidal each year, its threat looms ever larger. Logically, such a threat is remote. But since bureaucrats and politicians are seldom logical, nuclear war could occur at any time.

However, there are some misconceptions concerning nuclear war which makes its likelihood seem greater than it actually is at this time.

First, we are led to believe that Russia has a nuclear defense setup which would save up to 80% of its populace. Such estimates are absurd. Even if Russia had shelter capacity for the 200 some odd million people that figure represents, this would only make matters worse.

Surviving a major nuclear attack is only the beginning. The devastation of the cities, industries, croplands, etc., would insure the certain death of the majority of survivors.

Many seem to think they would simply load this vast horde of survivors on transports and have them invade America. But aside from highly mobile weapons systems dodging American missiles on the world's oceans, Russian shipping would be pretty well wiped out.

If the Russians got in the first punch and destroyed America's capability to fight outside our borders, so what? To destroy America as a functional system is no guarantee of any successful invasion.

The examples of past invasions of Russia and China should convince anyone that conquering continents takes more power than any nuclear survivors will have left.

America is vast, 2700 miles wide by 1600 miles thick. On the occasions I've flown from coast to coast, I've been impressed and even bored by the emptiness of our land. The logistics of subduing all that space would be beyond the capability of even present-day Russia. Nuclear survivors would not even attempt it.

Besides, the Russians remember the problems facing the German invaders and the damage done to them by guerrillas. The Russian guerrillas were amateurs, compared to Americans. And the Americans didn't have much luck subduing the Vietnamese. Modern techniques of guerrilla warfare make the armed civilian more than a match for any army of occupation.

America has more weapons in civilian hands than are owned by the rest of the world combined. Civilian disarmament is only a Liberal's fantasy. Books on improvised weaponry are so widely distributed that even total confiscation of guns, if possible, would only be wasted effort.

Total surrender to Russia by our government, before a bomb was dropped, would serve only to destroy our government and bring on nationwide anarchy. No Russian general would willingly send his men into a mess like that.

Too many people see Russia as a monolith just waiting for an excuse to attack. The reasoning is that as they get hungrier they will have less and less to lose by attacking.

This would be logical except for the Chinese. The Mongols were the most successful invaders of Russia. Their sheer numbers made them invincible. Modern Chinese see the Mongols as their ancestors, although, technically, they weren't. At any rate, the Chinese believe they have a right to Siberia and other areas controlled by Russia.

The Chinese and the Russians have hated each other for centuries and no similarity of ideology will change that. Moreover, each considers the other, not America, to be the major threat to its existence.

Russia has more men on the Sino-Soviet border than in the Warsaw Pact forces. Estimates of Chinese military personnel and civilian militia on or near the border, prepared for invasion, are as high as 100 million.

Russians are so certain of a Chinese invasion that they won't allow a Chinese restaurant in their land, lest it harbor a spy. That's just a little item the position thus determined. These adjustments having been made, paint the box, inside and out, a coat of dead black. Everything should be painted black except the reflecting surfaces of the tin reflectors and the incandescent-lamp bulbs. The front board having been fastened, subsequent focusing can be effected by shifting longitudinally the lens board of the camera. The image of any sort of a picture that will fit in the holder can be reproduced. Colored post cards will project in their natural tints.

To make enlargements with the same box, a few minor changes are necessary. When employed for enlargements the tungsten lamps, which are required for projection, are not used. They may, however, remain in the box and can be disconnected from circuit by unscrewing them a few turns. The negative, or film, which is to be enlarged, is held in the opening E. Where a film is to be reproduced, it is held between two pieces of glass which are fastened to the inside of the front board with small clips. If a glass negative is used, the two additional glass plates are unnecessary. If the negative does not fill the opening in the camera, a mask cut from heavy black paper will be required to cut off the light.

The light for the enlargement is furnished by another tungsten lamp mounted in a porcelain receptacle which is screwed to a board which constitutes a base. This light source is moved about in the house until it is directly back of the opening E in the front of the box and until the light is distributed equally over the entire negative. To focus, move the camera backward or forward. While focusing, use a yellow glass, or ray screen, to cover the lens. When focusing has been completed, the shutter is closed and the ray screen removed. Then stop down the lens to bring out detail, and expose.

Completely Homemade Ice Cream

by Susan Kramer and Mike Thompson

Commercial ice cream is one of the most adulterated foods on the market. Ethylene glycol (same chemical they use in anti-freeze), formaldehyde, and rat poison are just a few of the goodies you may be eating in your luscious looking sundae. So why not take the time to make your own ice cream?

Get yourself a nut and a bolt, a quart

which happens to be true.

The Chinese are just waiting for Russia to get into it with America. Then they will pour across the Sino-Soviet border in waves of millions and millions, through the rain of atomic missiles, over the fortifications, and then on to Moscow.

The Russians know that a war with America would mean an automatic war with China. No matter how desperate they become for food and resources, an adventure against the Americans would only set them up for slaughter by the Chinese.

So don't be bothered by Russian threats and political doubletalk over here. But don't discount nuclear war as an impossibility.

America, Russia and China are becoming desperate for resources. Russia and China have oil enough for their immediate goals, since only a small percentage of their supply is used by civilians. But their future economy and military needs demand that they latch onto the fabulous wealth of Africa.

American politicians are just as intent on grabbing Africa's resources as are the others, but they are not so obvious about it. Before he left office, Henry Kissinger was over there trying to get the Rhodesians to sell out and leave. His next move would have been a similar arrangement with South Africa. He felt confident that with the African whites out of the way, he could make solid agreements with the black nationalists. Then, in gratitude to Kissinger for removing the whites, the blacks would sell their resources to America, rather than to the Russians or the Chinese.

Of course, the Russians and Chinese are arming the blacks and promising them all the weapons, and even foreign personnel, to do the job. Whoever wins, it will be the same for the blacks as it was in the 19th century. Whether a mine is operated by the Americans, Russians, or Chinese, the foreigners will get the minerals and the Africans will get the shaft.

During the 19th century, Europeans divided Africa among themselves and there was little friction. But three major powers who need so much will not make such divisions. Each group wants it all.

I believe Africa will be where it really begins. One confrontation after another is inevitable. As the Russians commit more men and resources to Africa, the Chinese will send more men to the Sino-Soviet border.

Sooner or later, the Chinese will invade and the Russians, fearful of America, will try to knock us out so we can't invade. Then everyone with nuclear missiles will dump them on whatever foreign devil is handy.

This doesn't worry me since I've taken nuclear war into account. Survival shelters of my design will keep the inhabitants safe for months. In coming issues I'll detail such plans which any capable person can utilize.

Proposed and present Civil Defense survival shelters are mainly death traps, both the family and the group types. A two-week survival shelter is an absurdity. Your need for shelter and guaranteed sustenance will last for months, not weeks.

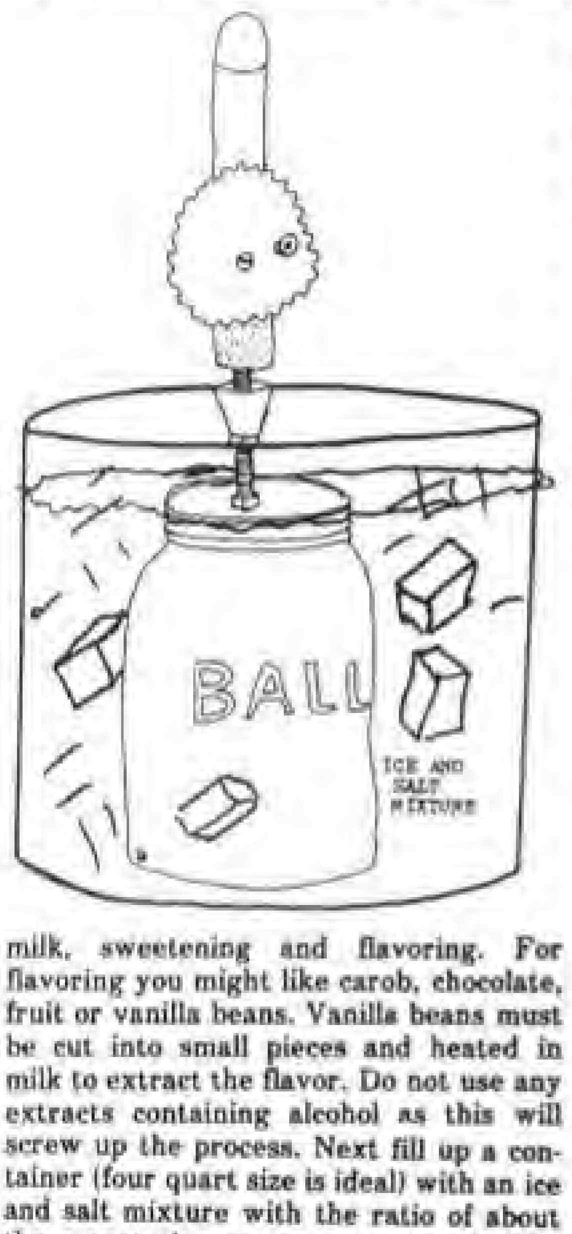
The idea is to have homes with as much area underground as above. A foot of concrete, steel and earth between the shelter area and the aboveground quarters would insure a family's survival from anything but a direct hit.

If you plan such a shelter, here is an instance where you should not tell your neighbors unless they too show the same interest in a permanent underground home. In the meantime, you could still urge them to make such preparations as I've outlined before. A person who prepares for one calamity is already well on the way to preparing for a worse one.

Of course, you probably couldn't keep such preparations secret from your neighbors anyway. But don't worry about that. Once you are tucked in, you can wipe out anyone upstairs at the push of a button. Holocaust, rioting, famine, plague, will not affect you. You can stick your head out often enough to see how things are going.

In future issues I will detail survival homes anyone can build themselves with little money. But unlike the publicized fallout shelters, useless now except for storage, these will be livable and an actual part of the home. In this way, you won't see such a shelter as simply an extra expense in your survival budget.

jar, and any gear driven hand-drill. If you don't have a hand-drill, you may want to read instructions for a home-made one on page 122 of the "Survivor", volume one. Punch a hole the size of the bolt you plan to use in the center of the jar lid. Starting from the bottom of the lid, push the bolt through the hole and fasten with a nut. Clamp the end of the bolt into the hand-drill. Now fill the quart jar with an ice cream mixture consisting of creamy



milk, sweetening and flavoring. For flavoring you might like carob, chocolate, fruit or vanilla beans. Vanilla beans must be cut into small pieces and heated in milk to extract the flavor. Do not use any extracts containing alcohol as this will screw up the process. Next fill up a container (four quart size is ideal) with an ice and salt mixture with the ratio of about three parts ice to one part salt. Salt in the ice makes it possible to obtain a temperature of below 32 degrees. Place the jar with the ice cream mixture into the center of the salt and ice container. Attach the drill and begin turning very slowly for the first five minutes. Then a faster speed can be maintained. You should open the jar when the mixture begins to get hard, and scrape the sides of the jar so that the mixture can harden throughout. When the entire mixture looks just like ice cream, you're done!

In the meantime, price home power plants. A gasoline or methane driven generator will supply the electricity. Several 55 gallon drums filled with fuel and water will last for months if used sparingly.

Grains bought in bulk and sprouted for humans and rabbits will insure against hunger. Good books, tools and compatible shelter mates will help pass the time.

WEATHER FORECASTING

By DON CART

Interrupted communications will mean interrupted weather service. Be prepared to forecast your own weather. The U.S. Weather Bureau has prepared the following chart.

Barom'tr	Wind from	Weather Indicated
High and steady.	SW to NW	Fair & little temper'ture change for 1 or 2 days.
High & rising rapidly.	SW to NW	Fair followed by rising temperature & rain w/in 2 days.
Hi & falling slowly	SW to NW	Rain in 24 to 36 hours.
Very hi & falling slowly	SW to NW	Fair and slowly rising temperature for 2 days.
Hi & falling slowly	S to SE	Rain within 24 hours.
Hi & Falling rapidly.	S to SE	Increasing wind w/rain in 12 to 24 hours.
Hi & falling slowly	SE to NE	Rain in 12 to 18 hours.
Hi & falling rapidly	SE to NE	Increasing wind w/ rain in 12 hours.
Hi & Falling slowly.	E to NE	Summer, light winds, fair; winter, rain in 24 hours.
Hi & falling rapidly.	E to NE	Summer, rain in 12 to 14 hours; winter, rain or snow & increasing winds.
Lo & Falling slowly.	SE to NE	Rain will continue for 1 or 2 days.
Lo & falling rapidly.	SE to NE	Rain & high wind; clearing & cooler in 24 hours.
Lo & rising slowly	S to SW	Clearing soon & fair for several days.
Lo & falling rapidly	S to SE	Severe storm soon, clearing & cooler in 24 hours.
Lo & falling rapidly.	E to N	NE gales w/heavy rain or snow, followed in winter by cold wave.
Lo & rising rapidly	Going to W	Clearing & colder.

A home weather station will be a definite advantage to you. First you will need an aneroid barometer. If you buy a new barometer, do not bother setting it according to the directions. All you will be using it for will be to determine whether the barometric pressure is rising or falling. You will also need a wind direction indicator. You can use a tree or a vane. You don't need to worry about wind velocity; just note whether it is light, medium, hard, or extra hard.

You will also need two thermometers. Mercury thermometers are more accurate than alcohol thermometers, but are also more expensive. The first thermometer is to record the temperature. The second is used to measure relative humidity.

To make the second thermometer serviceable to measure relative humidity, attach a cotton wick to the bulb at the bottom of the thermometer. Next bore a hole at the top of the thermometer (be careful not to break the glass tube). Attach a round handle to the thermometer in such a way as to allow the thermometer to swing freely.

To use, record the temperature on the thermometer. Wet the wick with alcohol (water will do, but is not as good) and twirl the thermometer for thirty seconds. Record the temperature which will be lower. Divide the higher temperature into the lower, subtract the result from one, and multiply by 100%. This will give you the relative humidity. For example, if the higher temperature was 65°—60÷65=.12; 1-.12 =.88; .88x100%=88%.

You may wish to have a rainfall indicator. Build a wooden box so that the inside height of it is the height of the beaker you will use. Have the top slanted away from the center. Bore a hole in the center of the box, the hole being the same size as the diameter of the beaker. (Drill several small holes in the bottom of the box for drainage). Put a door in the box. Set the box with a beaker in it out in the open and you're all set.

Keep a log of your weather observations and record them every 12 hours.

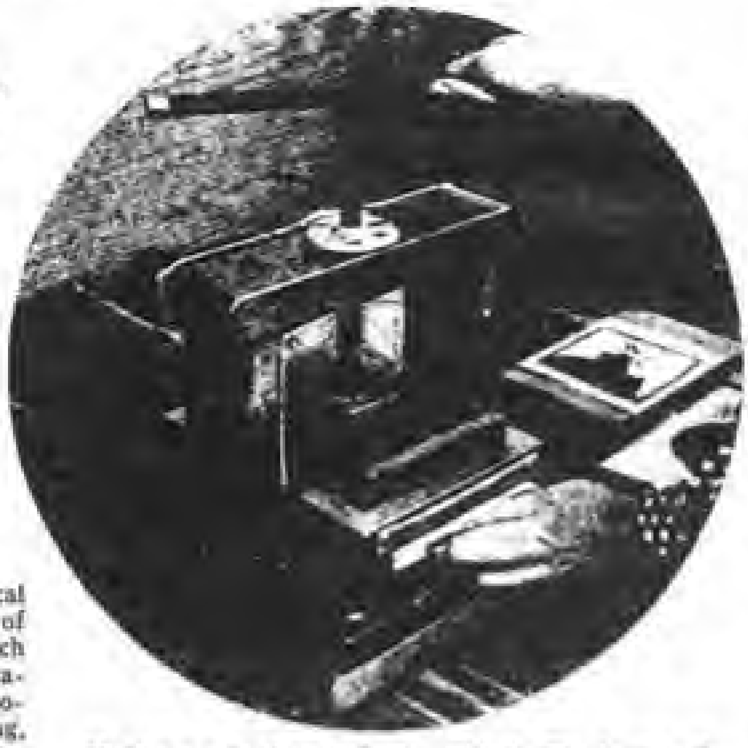
Two Helpful Hints

1. Keep your thermometer in the shade, protected from the wind for a more accurate reading.

2. Turn your television to channel 13; turn the brightness down all the way. Now turn to channel 2. When a tornado is in your area, the television screen will become very bright.

Utility Press

FOR BLOCK PRINTING



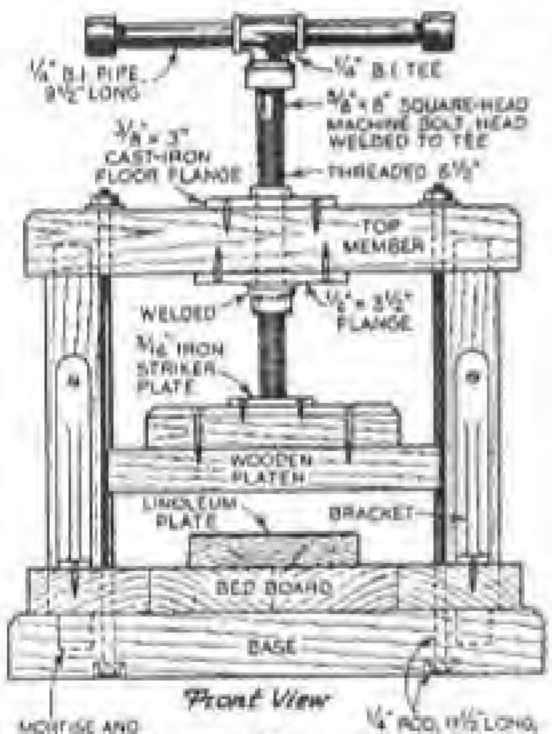
Making a print from a linoleum block. The bottom of the platen is padded with cloth thumb-tacked to the ends

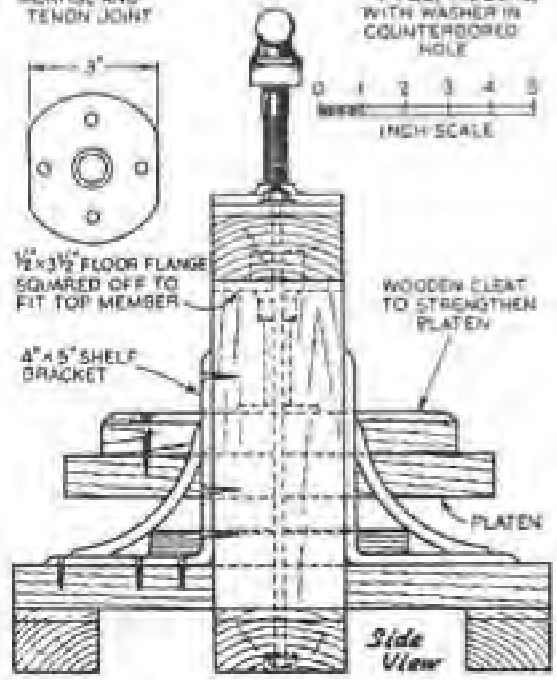
THE design of this practical screw press is the result of considerable experience and much experimentation in the use of various types of presses for linoleum-block printing, bookbinding, veneering small panels, making inlaid pictures, and other gluing and pressing operations. The bed will take work measuring 7 by 16 in. or smaller.

Either oak or maple is used for the wooden parts, and the total cost should not exceed three dollars. The entire assembly is screwed and bolted together. Glue is used for the mortise and tenon joints, and four shelf brackets stabilize the side supports.

The working drawings show the size and position of all members, and the list of materials has been determined from actual working conditions. Only two suggestions are necessary to assist the novice. First, the two outside bed boards are to be scribed and cut to fit tightly around the side supports; second, the platen is to be grooved at the center of either side deep enough to form a guide working against the 1/4-in. rods.

It is an excellent plan to oil, varnish, or shellac the wooden parts.—



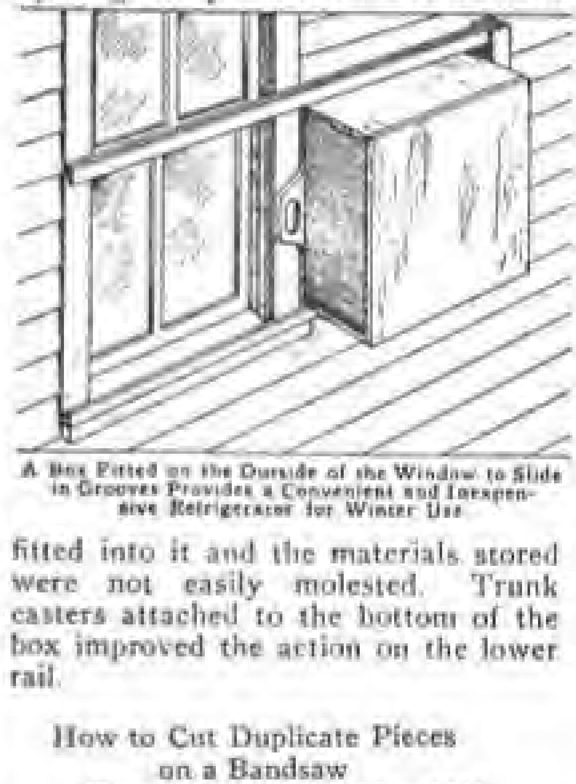


List of Materials

2 pc. 1 1/2 by 2 by 12 1/2 in., for outside bottom supports.
1 pc. 1 1/2 by 3 by 12 1/2 in., for middle bottom support.
4 pcs. 1 by 2 7/8 by 12 1/2 in., for bed.
2 pcs. 1 1/4 by 3 by 9 1/2 in., for side supports.
1 pc. 1 1/2 by 3 by 11 1/2 in., for top member.
1 pc. 1 by 7 1/8 by 10 in., for platen.
1 pc. 1 by 6 by 8 1/8 in., for platen cleat.
Note: This material is either oak or maple.
2—11 1/2 by 1/4-in. hex-head rods, with washers and nuts.
4—4 by 5-in. wrought steel japanned shelf brackets with 24 flathead black wood screws, 3/4-in. No. 6.
1—8 by 3/8-in. squarehead machine bolt, threaded 6 1/2 in., with nut.
1—1/2 by 3 1/2-in. cast-iron floor flange, to be welded to 3/8-in. machine-bolt nut.
1—3/8 by 3-in. cast-iron floor flange, reamed to form collar for bolt.
1—1/4-in. black iron tee reamed to receive 1/4-in. pipe handle and welded to head of 3/8-in. machine bolt.
1—1/4 by 9 1/2-in. black iron pipe, threaded both ends for handle.
2—1/4-in. black iron pipe caps, for handle ends.
1—2 by 3/16-in. flat iron for striker plate, drilled and countersunk for four No. 6 flathead wood screws.
24—1 1/4-in. No. 6 flathead bright wood screws, to fasten bed to bottom support; 6—3/4-in. No. 6 screws, for striker plate and 3/8-in. floor flange; 4—3/4-in. No. 6 screws, for 1/2-in. floor flange; and 4—1 1/2-in. No. 6 screws, to fasten platen cleat to platen.

A Window Refrigerator

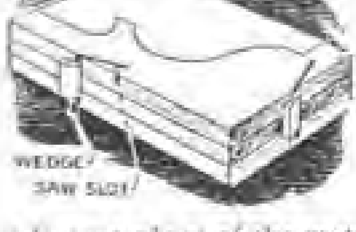
A simple method of constructing a window refrigerator that will not obstruct the light is shown in the illustration. A box was made the width of the window and was fitted to slides fastened outside the window on the side of the house. The exposed sides of the box were inclosed completely and the inner side was provided with two sliding doors. A handle was fitted to the side of the box so that, by reaching out of the window, the box could be drawn in front of the opening easily. Several shelves were fitted into it and the materials stored were not easily molested. Trunk casters attached to the bottom of the box improved the action on the lower rail.



A Box Fitted on the Outside of the Window to Slide in Grooves Provides a Convenient and Inexpensive Refrigerator for Winter Use

How to Cut Duplicate Pieces on a Bandsaw
From Popular Mechanics 1928

It is often necessary to cut out a number of duplicate pieces on a bandsaw. Sawing three or four at once means, of course, quite a timesaving, but the pieces must be securely held together during the operation. An easy means to this end is to cut two or more tapered slots, about 1 in. deep, in two adjacent edges of the material as indicated and then drive a small wedge into each slot. The wedges will hold the pieces together firmly and prevent their slipping apart while the sawing is done.



SERIOUS SURVIVAL FISHING

By Jim & Stephanie Watters

Serious survival fishing is based on these assumptions: 1. You need enough fish to feed a hungry family; 2. Due to some risk factor (such as hostile survivors or unsympathetic game wardens) you don't want to spend too much time at the scene; 3. Due to those same risk factors you need methods that leave no sign of your activities in the area.

These are serious problems that rule out most conventional fishing methods. But poor folks down here in the South have been getting around them for years. Most of them use some type of trap.

One of the easiest traps to make is constructed from old automobile tires—one of America's most plentiful unnatural resources. Lace the sidewalls together with wire or heavy string. Stand the tire up and cut three or four holes into the tread about 2½ to 3 inches across. These will be for fish to swim into to hide or to eat the bait. Now, directly down from the big holes you cut, gouge several small holes into the tread, and it wouldn't hurt to gouge a few into the sidewalls if you're not very strong. These are to let out the water when you go to pull up your trap. Keep them small or you'll lose the tasty crayfish that often go into the tire along with the catfish, perch, turtles, eels, and crabs. Tie a rope or wire around the tire at the top where you cut most of your entry holes. That way when you quickly pull up your catch, they will not be able to swim out.

Tire traps sometimes work without bait because fish use them for hiding places, but they're most effective with bait. Spoiled left-over food, rabbit guts, almost anything you can think of will work. The worse it smells, the more action you'll get.

Set your tire traps in the bend of a creek where the water is deepest, and conceal the rope leading to it. Try not to leave too many tracks in the soft mud and check your traps from a different approach each day. When you clean your catch, save the guts and scraps for bait; don't leave scales on the bank.

If you can scrounge enough old wire fencing, you can make a very effective trap that I prefer to all others. Make a cylinder of the fencing about 10-20 inches in diameter and three to four feet long. (I have used bigger ones but they are hard to carry along a woods path and require much deeper water for complete concealment). Over this cylinder of heavy fencing wrap some small mesh stuff like that used for chicken coops or rabbit hutches. Close up one end of your cylinder completely.

Next, make a funnel of the small mesh wire and fasten it into the other end. Leave an opening in the end of the cone of 2½-3" diameter. Now to get your fish out more easily, cut a flap in the small mesh wire somewhere on the side of the cylinder, and cut out one mesh in the heavy form fencing beneath it. Tie it shut with three or four pieces of soft copper wire. Tie a rope or wire (which is easier to conceal) to your basket trap and head for the water with some good stinking bait tied up in an old sock or even table scraps in a paper sack (so they won't wash away too quickly). Follow same directions as with tire traps.

Basket traps are also very effective when placed in culverts or drainage pipes or any narrow place in a creek or canal. We sometimes catch muskrats in them. If you want more rats than fish, use apples and cattail roots for bait, and make your funnel opening a little larger. Or you can catch big snapping turtles by using a bigger funnel and a bloody bait.

The muskrats are very good eating if you remove the musk glands in their hind legs. Their fur is soft and very long-wearing. The snappers are good eating; all turtles are edible, but the snapper is especially good. You can expect to catch all kinds of turtles in a basket trap. I don't recommend stink turtles or horse turtles, but the others aren't bad if you stew them.

If you can't find the fencing to make the cylinder for a big basket trap, you can make a box frame trap of wood and cover it with any small mesh wire—the smaller, the better. Instead of a funnel opening, make it like an inverted pyramid. These traps work well, too, and are easier to conceal in shallow ponds.

If you're living out of your backpacks and can't scrounge any tires or fencing for traps, you can still get plenty of fish for your family. Find a black walnut tree and pick up a sackful or a shirtful of walnuts with the husk still on the nutshell. Pound them up, tie them into your shirt or bag and with the line attached, throw into a pond or slow-moving stream. In just five minutes you'll be able to pick up fish coming to the surface. You can use the mashed up berries and leaves from a chinaberry tree also. It's very common around old homesteads here in the south. I've also heard that crushed poke salad roots and berries will work but I've never tried them because I know they're poisonous to people too. Whatever you use, when you get enough fish, pull out the bag or you will destroy all the fish there, and that's stupid.

There are other methods of serious survival fishing, but these are the ones I'm best acquainted with because they are best suited for my area. In your retreat area, you should determine which type would be best for you. If you are going to be near the ocean or even a little creek, find out how the local poor people trap fish and crabs. I got a lot of good information on illegal but effective fishing methods direct from our local game warden! If you have the money, but a few commercial crab pots or fish traps and use them for a pattern to build more.

Whatever method you use, if you do it right, you'll catch more fish with less work than you will with hook and line. And most important, you can do it without as much chance of giving your location away to roving scavengers. Here on the east coast, it is definitely a better way of getting protein under survival conditions than trying to hunt small game. It's easier and safer for the beginner or the old expert. So save your ammo and try some SERIOUS SURVIVAL FISHING!

MINI AND MAXI SURVIVAL KITS

By Alfred Orel Norton

The mini and maxi survival kits were developed by Ron Hood who operates a survival school in southern California as well as teaching survival courses at the University of California at Los Angeles.

One should always carry the light-weight mini kit on one's person: either around the neck or in a pocket. The kit's contents may be placed in a 35 mm. film canister. The kit is useful for general camping as well as personal survival. The kit's contents are: 5 windproof and waterproof matches, 2 exacto razor blades, 15 feet of 8lb. test monofilament fish line, five number 14 trout hooks, five B.B. split shot, fifteen feet of number 24 brass wire, 4 small safety pins, five feet of 1" adhesive tape, one dime, one shoe lace, five aspirin, a bouillon cube, a needle, a toy balloon (long), a match striker, and a whistle.

The windproof and waterproof matches, which may be split down the middle to produce ten matches, are invaluable in starting a fire. They burn for seven seconds giving off a very intense flame. Of course, one brings the small portion of a match striker to ignite the matches. If facing extremely difficult weather conditions, such as, rain with high wind, these matches will provide the spark for a warm fire.

One can attach an exacto blade to a

thin piece of wood by using some of the adhesive tape. The knife will aid one's cleaning a fish, and will also serve as an eating utensil. One can also use the knife to make incisions if bitten by a poisonous snake.

Since fish are a good source of protein, and in case of being marooned at sea a source of fresh water, the fishing tackle in the mini kit is extremely useful. Monofilament fishing line is strong and compact. If not used for fishing, one can use it for tying, sewing, or making a snare. The B.B. shot serve as sinkers. One can also gig the fish by hooking the fish anywhere and pulling it in. After all, your life is at stake. All's fair in survival.

The brass wire can be tied in an elliptical loop to form a snare. Also it can be used for general tying or binding. This wire could be used in lashing sticks together to form a large spear.

The safety pins are invaluable in the repair of rips in clothing or equipment. Also an open safety pin can serve as a fish hook.

Adhesive tape helps in first aid. By forming butterfly clips, it can be used to close wounds. This means that one need not have a suture kit, complete with cat gut. One can also tape blisters which are easily formed on the trail. In winter, snow blindness, produced by the snow's reflections, can cause total disability for several days. The adhesive tape can be used to make snow goggles by taping over regular eye glasses leaving only a slim slit for visibility.

The dime can be used to call for help. It also makes a fishing lure, attracting fish by its reflection.

Not only can the shoe lace be used to carry the mini kit around the neck; it is also useful as a bow string for a fire-making bow. In order to use the bow, one attaches the shoe string to both ends of the branch or bow, allowing enough slack to permit it being twisted once around the drill. By turning the drill over the string the resulting heat will ignite the tinder in the fire board's notch. After the tinder's ignition, remove the board and fan the tinder until it bursts into flame.

The bouillon cube provides salt and can be used to flavor wild foods.

The needle is invaluable in removing splinters and draining blisters. By using the fish line or thread from a garment one can use the needle to sew. If magnetized the needle can serve as a compass needle.

The balloon serves as an emergency canteen It will hold up to three or four quarts of liquid. A tied-off short sleeve will make a carrying sling for the filled balloon.

help. It saves one's wind and is more effective than shooting.

The Maxi kit can be carried in a coffee can. Together the Mini and Maxi kits offer the full range of survival skills. The contents of the Maxi kit are: four feet of surgical tubing, a file (half of a 6" file), a plastic tube tent (1 man), a whistle, compass, knife, thirty feet of nylon cord, a candle, a Mallory flashlight, half a road flare, 2 or 3 zip lock bags, and a small can.

By punching two holes in the coffee can, one can insert a length of wire and carry it easily.

One can use the tube tent and surgical tubing to construct a solar still. Puncture a pin sized hole in the tent at a point which will be over a water container. After digging a 2½' wide by 2' deep hole, line the hole with vegetable matter. Place the coffee can at the center of the hole below the hole in the plastic. Support the plastic with rocks. Using a stone have the plastic about two to three inches above the can. Before using the plastic one should roughen one side using sand or a rock. When water begins to drip, be certain it's falling into the can. The surgical tubing allows drinking of the water without disrupting the distilling process. Incidentally, the solar still will produce up to three pints of water per day. Several stills can be made by cutting the tube tent, for one needs at least two quarts of water per day. The zip lock plastic bags can be used as reserve canteens in addition to the balloon.

The surgical tubing can be used for the motive force for snares or can be used to make traps or a slingshot. Also it will serve as a constriction band in first aid, such as for snake bite.

The file, preferably a bastard file, can be used for flint and steel fire making. It also can be used to sharpen knives and offers a good surface for striking matches. Finally, the file can be used for making wood or bone tools.

The tube tent (3 ml. thick), made of clear plastic, offers shelter and serves as a ground cloth or rain tarp.

When using the whistle, blow three times—the international distress signal. Whistles are useful for signalling other members of the party and scaring away animals, such as, cattle.

A Silva compass is essential for navigating. Such compasses range from the Polaris ($4.50) to the Ranger ($24.95). All Silva compasses have an adjustable bearing marker and a straight edge. This makes taking bearings, back bearings, allowing for declination from true North, and orienting a map much easier.

A knife is the most important survival tool. The knife should be of high quality, such as, a Swiss Army Style by Victorinox or Wenger. The Buck hunting knife is acceptable.

The thirty feet of nylon cord should be at least 260 pound test. One can use it to erect the tube tent by tying the cord to two trees and suspending the tent on the cord. One can hang food over a tree limb, hopefully keeping it out of reach of bears and other varmints.

The candle is useful for light. A scented candle is preferable. Be careful that the candle does not tip over. One should not have the candle in the tube tent as tents are extremely flammable. The candle Will heat a small container of food or start a fire in wet conditions.

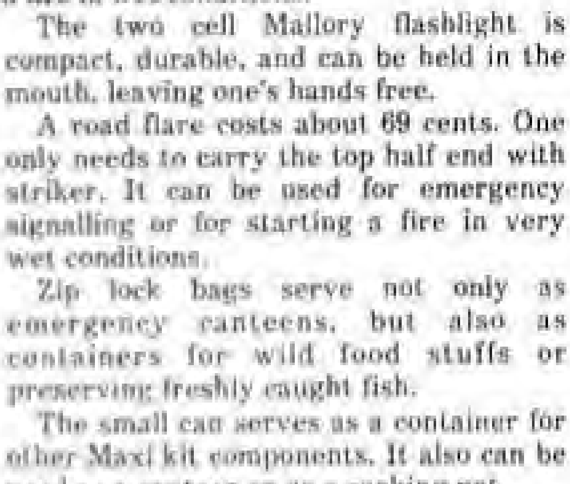
The two cell Mallory flashlight is compact, durable, and can be held in the mouth, leaving one's hands free.

A road flare costs about 69 cents. One only needs to carry the top half end with striker. It can be used for emergency signalling or for starting a fire in very wet conditions.

Zip lock bags serve not only as emergency canteens, but also as containers for wild food stuffs or preserving freshly caught fish.

The small can serves as a container for other Maxi kit components. It also can be used as a canteen or as a cooking pot.

In order to cut costs, make four or five kits. One can include in the Maxi kit a wire saw for cutting firewood and constructing a shelter. Also one can bring some Chia seed in a small salt or pepper shaker. Chia seed is high energy concentrated Indian food.



Lois and David Bassett in front of home.

Family living in plastic house

WAHKON, Minn. (AP) — David and Lois Bassett and their three children are snug and warm, even though several layers of plastic sheeting is all that separates them from temperatures as cold as 48 below zero.

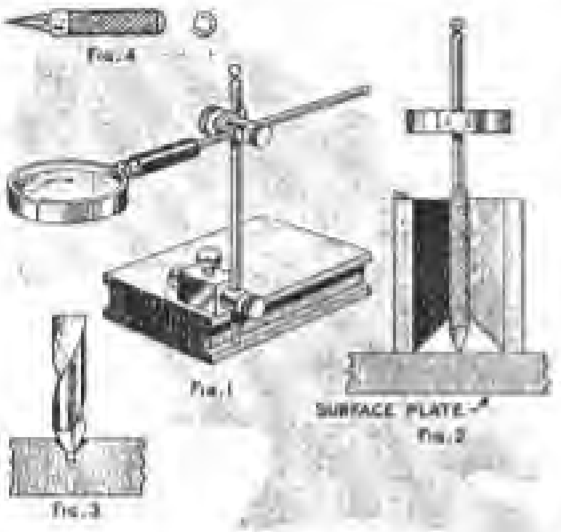
The Bassett family is spending one of the coldest Minnesota winters on record in a shelter made of tree branches covered with polyethylene sheets.

Bassett, 25, said the winter weather scared the family a little, but they wanted to get onto their own land so he built the shelter near Mille Lacs Lake in central Minnesota in November.

Kinks on Accurate Drilling

From Popular Mechanics 1928

I have been using a few kinks in laying out jig work for the drill press with great



Sharp Tools and the Application of a Few Handy Kinks Will Help in Drilling Accurate Holes

success. A large magnifying glass, held by a clamp so that the worker's hands are free, is better than a small one. One method of holding the glass is shown in Fig. 1. It can be set to any angle. If no precision center punch is available, the surface gauge or a V-block can be used as in Fig. 2. This keeps the punch at right angles to the work. A flat scriber of the kind shown in Fig. 4 should be used, as a round one sometimes causes inaccurate work. The punch should be accurately ground to a sharp point, which will facilitate marking the work at the intersection of two lines. Use a center combination drill of a diameter smaller than that of the center-punch mark, and make the angle sharper. For instance, if the center punch has an angle of 60°, that of the drill should be about 70°. Then follow this up with a drill like the one shown in Fig. 3. This has a tendency to make the drill follow the hole. If dividers are used, keep them sharp at all times. Whenever possible, use a scale graduated in fiftieths or hundredths of an inch, because the lines on these scales are finer than those on more coarsely graduated rules. Such fine graduations enable you to set your dividers more accurately. If you are not sure of the accuracy of a layout, drill small holes, that is, smaller than the finished size, insert the drill rod of the correct size and measure over all with a micrometer. If there is any error, use a round file to enlarge the holes so that the next-size drill corrects the error. I have found that it pays to blue the work, even though it costs more than rubbing bluestone on it, as this enables you to see the lines more clearly. If the above rules are strictly followed,

SURVIVAL AND THE PARANOID

by Kurt Saxon

..."**One suggestion**; you should have the newsletter folded the opposite way. The large title attracts the attention of the mail people and people's family. I don't want everyone to know that I'm stocking up and thinking they can come to me for help. So please have THE SURVIVOR folded backside out"...

..."**I'm also wondering** if it is possible to have a subscription to your publication, THE SURVIVOR, and/or back issues, sent to us in plain envelopes, First Class, if necessary. Inasmuch as we live in a very conservative community, receiving your publication in a plain envelope would prevent alarming our local postmaster!"...

The above two writers may not be clinically paranoid but they demonstrate the simple inconvenience of paranoia. Both are so afraid of their own neighbors that they will miss out on THE SURVIVOR. No big thing in itself. But what else are they missing out on just because they don't dare let their neighbors in on their preparations?

The term "paranoid" is used constantly but hardly understood. The clinical definition of paranoid is one with delusions of grandeur coupled with feelings of persecution. (A lesbian is a mannish depressive with delusions of gender—pass it on). A paranoid believes he has gotten to the hidden truths of matters most important to him. He also believes that such knowledge makes him dangerous to those actually running things.

Believing there are enemies all around, fantasizing about plots and such, gives him a feeling of importance, of being in the know. But that feeling of importance is counteracted by the terror of the realization that one's enemies will step on him like a bug once he learns enough to be really dangerous to them.

Paranoids can't accept our social decline as a result of climatic change, surplus population, reduced resources, mental defectives and other natural influences which have been knocking out civilizations throughout history. No, paranoids see a plot behind the whole thing.

Some group, easily identifiable to the initiated and aware, is manipulating civilization. Our collapse is imminent. THEY are destroying everything THEY can't control when the time comes. Then, THEY will step in, run up THEIR flag and assume complete control. THEY will then destroy all those who anticipated THEIR fiendishness.

Of course, these Agents of Darkness have sympathizers in every neighborhood. THEY are also entrenched in the Justice Department with links to every local police station and dog pound in the United States.

So the idea of surviving civilization's collapse is actually incomprehensible to the paranoid. He may play at survival but THEY will win in the end. Of course, it all depends on security.

To the paranoid, his only chance lies in secrecy. If a few hundred of the right type can survive, in spite of all the traitors planted in their midst, good will eventually triumph.

The above doesn't fit every paranoid but too many hold to this general pattern.

When I began THE SURVIVOR, an old man wrote to me about his homemade security system, his advanced age and his ability to survive whatever adversity might strike. I thought he was such a fantastic old man I wanted to share him with others as an example of self-reliance in old age.

I printed his letter and address, thinking he would like to correspond with elders in like circumstances, or young folk needing a granddad figure. As soon as he got the issue with his letter in it he sent me a screaming note about how I'd exposed him to the world, lowered his property values and generally put him in jeopardy.

I answered saying that no one else within over a hundred miles of his town took THE SURVIVOR. If his homemade security system was offensive to a and the tools are kept in good condition, no trouble will be experienced in drilling holes within limits from .003 to .005-in. center-to-center distance.

Fixture for Forming Wire Links

From Popular Mechanics 1928

A Simple Jig Which Will Facilitate the Making of Links of Equal Size

An inexpensive fixture for forming eyes or loops in wire links is shown in the accompanying illustration. It is designed to be held in a bench vise and consists of a block, A, into which are fitted two pins, the distance between their centers being equal to the distance between the centers of the loops or eyes to be formed. Two smaller pins, also driven into the block, locate the preformed wire centrally with the eyes. A hole, D, equal in depth to the length of the wire forming the eye, is drilled in the end of the block, and an adjustable stop, E, is tapped into the end as shown, and locked by a nut. The lever L, which is used for forming the link eyes around the pins, has a pin, G, and it is drilled at F to fit the link-forming pins.

The process of making wire links is as follows: First cut off the wire to the developed length of the links. Next insert one end of the wire in hole D and bend it until it touches stop E. Repeat this bending operation at the opposite end of the wire, being careful to keep the bends in the same plane, so that the partly formed link will lie flat in the fixture. At this stage of the forming operation the link is shaped as shown in the detail. The lever L is placed in position on one of the pins so that pin G engages the wire and the eye is then formed by rotating the lever about the pins, after which the forming operation is repeated at the other end of the wire, producing the complete link as shown in detail S.

realtor or a potential buyer it could be taken out with no loss of property value. Nothing I said mattered. He was going to sue if I didn't take his address out of the survivor.

I told him his address would be out the next printing, he had no case and he ought to get his head read. This might have calmed him down except some reader had to go and send him a letter. This started him off again and we had another go-round.

Nowadays I'd just have thrown his letters away, cancelled his subscription and forgotten him. But then I was concerned. I felt I had caused him anguish and wanted to make amends.

However, once you've gotten on the wrong side of a paranoid, there's no making amends. I'm now a part of the plot.

Anyway, my point is that paranoia is not funny. It is also a serious drawback to anyone's attempts to survive or to better himself on any level of endeavor.

Paranoia is simply exaggerated and useless fear. Normally, everyone is afraid at times. Normal fear leads to normal caution. But when fear becomes obsessive caution, distrust and universal suspicion, it becomes paranoia.

For instance, say you decide to become a tightrope walker. If you are clumsy and awkward and hung over and strung out and normal, you will fear falling because of a lack of ability. If you really want to be a tightrope walker, you'll go over your shortcomings and eliminate them, thereby fitting yourself to become what you want to be.

But if you are paranoid, you will disregard any of your own short-comings. You will reason instead, that the Circus World is controlled by people who will feel threatened by any success you might achieve. Lest you become a star in their private world, they'll hire someone to shoot you off that highwire.

So the paranoid is actually a self-imagined winner, beaten before he starts. If he isn't actually mentally ill, he has an overactive imagination, putting non-existent obstacles in his own path. Instead of developing his abilities, taking his lumps and successes as they come, he relieves himself of the challenge by stacking the deck against himself. He's really just a cop-out artist.

Usually he has MBD (Vol.1 p 64) which keeps him in a state of arrested development. He's like a child who imagines himself the hero of his fantasies but sees his parents and elders as blocks to any successes he might achieve. An adult with this problem has lofty fantasies but replaces his elders with various authority and power figures who might feel threatened by his achievements. So he doesn't really try to improve his circumstances. In his fantasies he feels little guilt about being a loser. After all, if he weren't so magnificent and superior, would the forces of International Crud be united against him?

Every paranoid, however, has sane moments the same as I do. He realizes that whatever is really keeping him back, he's far behind and he's not very happy. Maybe something got in his way during childhood which made him stop testing the system. That's the key to it all; testing the system to see what one can get away with.

All children do, and if their elders understand and don't over-punish, the child will have a good idea what he can get away with and how far to go in finding his limitations. But if a child has overly strict parents, or MBD, punishment might be so severe, or seem to be, that testing the system is not worth the effort, or it may even seem downright dangerous. So the guy reaches adulthood, either not trying anything, as an individual, or becoming such a Secret Squirrel no one will ever know what he's doing.

This would be all right except the paranoid often tries to impose his own fears on others who share his stated goals. This can be a drag, especially in my case.

Years ago I saw books hinting at do-it-yourself mayhem. They promised a lot more than they delivered but suggested that any stronger stuff would be suppressed. Well, I'd dabbled in paranoid gutter politics for years and didn't believe such material could be suppressed. I set out to write, publish and sell the most outrageous, potentially destructive manual ever created on this

A HORSE DRAWN SOD CUTTER

From Popular Mech. 1919

The cutting of a considerable area of sod is tedious work when done by hand, and it is difficult to make the sections of uniform thickness and size. These important features are provided for by the use of the homemade sod cutter shown in the sketch. To start a cut across a meadow or lot, a notch is cut in the turf for the blade, and the device is set into place, stamping it down to give a good start. The operator stands

With This Device Sod may be Cut Quickly and of Uniform Width and Thickness

on the plank in front of the blade, and a little practice will soon determine the best position for ease in operation. When a cut has been completed, the cutter is dragged to a fresh starting place, the driver turning it over on the upper side. The strips are cut into suitable lengths and piled conveniently for removal with a stone boat or wagon.

The device may be made of any suitable width; 15 in. between the inner edges of the blade, and the latter set to cut a depth of about 2½ in., being desirable. The board is a 2-in. plank, about 4 ft. long. The blade should be set with the cutting edge slanting slightly downward so as to make the device "bite" into the ground. A smaller cutter may be made for use by boys, several of whom may draw it.

planet. If interested parties had the power to suppress knowledge, they would suppress the work you know as THE POOR MAN'S JAMES BOND.

Well, first I was talked to by the D.A.'s man and our local FBI agent. Interesting. Then I was subpoenaed to a Senate Hearing in Washington, D.C. They paid my plane fare both ways, put me up in a hotel room with TV and let me rave at a panel of bemused Senators. I had ever so much fun and got a lot of laughs.

There was not one request that I stop publishing the material; there was no threat to my person, my freedom or to my economic security.

I've sold about 40,000 copies of the work over the past five years with no interference from anyone. Yet, I still get orders for the PMJB which are wrapped in aluminum foil so Federal Agents can't read them by X-Ray. Some orders are so coded to protect the identity of the one wanting it that the book comes back marked, "Addressee Unknown". Paranoia!

Common sense might suggest that since it's legal for me to write it, publish it and sell it, a customer can legally own it. Despite the fact that, to the best of my knowledge, no one has ever been hassled for owning the PMJB, paranoids around the country consider ordering it the last thing they will be allowed to do before being led away.

No matter. What really bugs me about paranoids is their attitude toward THE SURVIVOR. THE SURVIVOR isn't an underground publication. It isn't political; it doesn't advocate any sort of criminality or extreme social activism. Nor is it pornography. THE SURVIVOR is a family publication. Plain envelope, indeed!

Anyone really interested in Survival will have to drop all his paranoid fantasies. The ones who inspired this editorial are too afraid of their neighbors to have an effective chance at surviving.

Survivalists must examine each fear and eliminate it. There are enough real things to fear without being hung up on imaginary fears.

Every fear is an unconfronted weakness. I'm no longer afraid of the calamities which face the general populace. I faced my fears and eliminated their cause.

At one time I thought my mail might be monitored. Instead of frustrating the monitors by going out of business, I called my postmaster and had a long talk about it, wherein it was explained to me how mail was monitored and why mine wasn't.

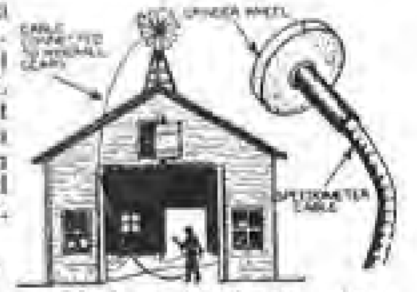
I think everyone gets flashes of paranoia where he entertains irrational fears. But rather than give in to such fears and work out elaborate habit patterns to reinforce them, one should go straight to the source and confront it.

Such an action not only eliminates a fear but makes it harder for new fears to settle in. Practice makes boldness and the Survivalist must be bold.

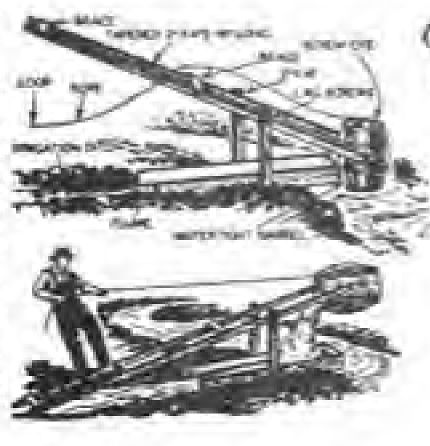
Cont. page 574

Windmill Powers Grinding Wheel Thru Cable

HERE'S a new angle on motive power for operating a small emery wheel. Lay hold of an old auto speedometer cable and hook one end of it to your wind mill (if you have one) and the other to the grinding wheel. Of course, the wheel will have to be geared up, about 2 to 1, but this will be a simple task. The wheel can be used in any position and can easily be carried about.



Modern Mechanics 1932



One Man Operates Irrigation System

A NOVEL and highly efficient one-man irrigation system is in use in many of the northwestern states. The scheme entails the use of a vinegar barrel, which is supported between the ends of two 2x4 inch pieces 16 feet long by means of lag screws. Two 2x4 inch pieces are then driven into the bank as close to the edge of the water as possible to support the arms. The ratio of the length of the arms should be approximately 1 to 4; that is, the barrel end should be 4 feet long, the operating end 12 feet long. The barrel is pivoted one inch above center so that it can be inverted easily. To operate, the arms are raised, lowering barrel into water.

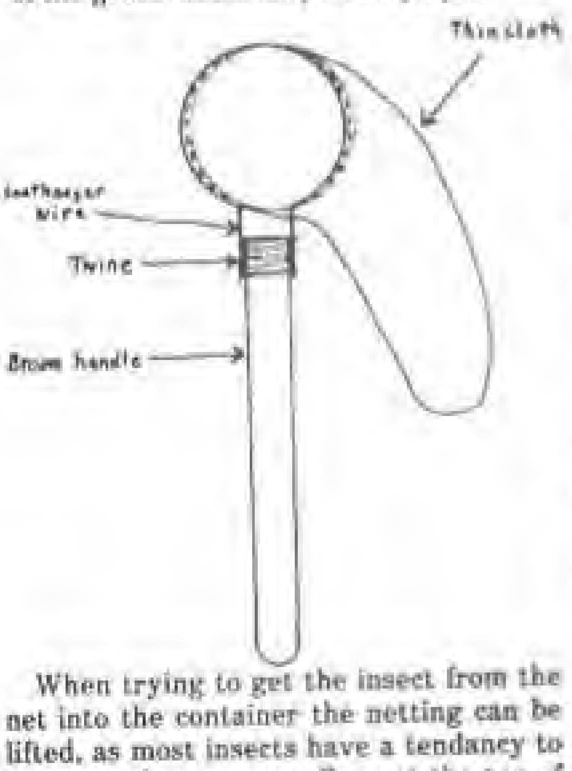
Capturing Insects for Livestock Feed

By Bill Abreu

In feeding fish, chickens, or whatever animals you might be raising, the best source of food to use is insects. Insects will provide them with ample protein, resulting in a healthy livestock. Also, insects cost nothing to capture and they need not be bought in stores, thereby leaving extra money leftover for survival needs.

Before you go ahead and start your search, however, it should be known that monarch butterflies and furry caterpillars can be toxic when eaten, so it is best to avoid these. But flies, grasshoppers, beetles, and small insects are excellent in feeding animals and the supply is always plentiful.

One way to catch insects is to go out and capture them in their own habitat using a net. The drawing helps to illustrate how a simple net can be constructed using household objects, such as a broom handle, thin cloth or panty hose, and preferably thick coathanger wire for the net's frame. For catching small insects which thrive in the grass, a sweeping motion (back and forth) just under the top of the grass blades may be employed.



When trying to get the insect from the net into the container the netting can be lifted, as most insects have a tendancy to fly upwards to escape. Once at the top of the net, the jar or container is slipped inside and placed over the insect. The lid is set over the top of the jar and the netting slid out of the way, allowing you to tighten the lid. Another way of getting the insect out of the net is to use an aspirator which will be discussed more fully in a moment.

If slightly stronger material is used in making the netting, aquatic insects can easily be captured. This method is especially simple in streams, wherein the net is placed in the water, letting the current sweep the insects into the net.

An aspirator is a device used for drawing an insect into a pill bottle container. A straw or stiff tubing is placed through one end of the bottle and a flexible tube of desired length is pushed through the other end. On the end of the rubber tubing is attached a small piece of screen to prevent the insect from escaping. The tube with the screened end is placed inside the mouth and when an insect is spotted, one strong inhalation breath is taken, sucking the insect directly into the bottle. A slightly improved aspirator can be used when close to an electrical outlet. Instead of using a flxible tube, the suction end of a vacuum cleaner is placed over the open pill bottle end. This system will allow you to pull in more insects at a much faster rate. Of course, the manual version must be used when there is no electrical supply present.

If this is too much work for you then there is an alternative. Rather than going out to catch insects, you can have them come to you. It is no secret that at nighttime insects are attracted to lights. There are different theories as to why they do this (one is that they confuse the light with the moon) but this is unimportant as long as you know how to make use of this instinct.

A white sheet is strung out against a wall and a light bulb placed in front of it. After a short while many insects (not just moths) will gather on the sheet where they can then be easily collected using an aspirator or net. A cardboard box can be used as a trap if the light is placed inside it and a small opening made at the bottom. Once the insects are inside they will remain trapped until morning when you are ready to collect them.

A trap for capturing ground insects can be constructed using a coffee can and some bait. First, a small pit is dug in the ground and the can placed inside so that the pit's depth matches the can's height. The insects are attracted by the bait's scent and they fall into the can, unable to climb back up the smooth metal walls. The best bait to use is a form of decaying vegetables or a sweet substance. A mixture of brown sugar, beer (use only a little so that you have enough for your next party), and molasses is stirred in a sauce pan with a medium flame until it forms a thick syrup. This bait can be placed in the above mentioned trap or can be applied, in patches, to walls or trees. When applied to these surfaces it should be placed where the odor will travel the best.

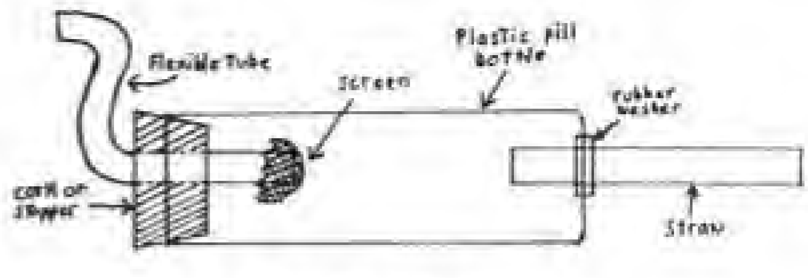
When looking for insects it should be remembered that they can be found almost anywhere: on trees, under bricks or stones, on leaves, between cracks, burrowed in the ground, amid moss, in streams, or in old houses. If you live in the city it is best to use the light and sheet method to attract them to you. Often silverfish (which are actually insects belonging to the thysanura order) can be found in bathtubs or sinks and though they can escape quickly, it is wise not to rule them out as a possible food source. If you have a garden you can find many small insects living there, in which case you can use the vacuum method (as mentioned on page four of THE SURVIVOR) as long as the vacuum bag is empty.

Another way to keep up your supply of insects is by breeding (or rearing) them at home. To raise crickets and grasshoppers a large container—like an aquarium or large can—is filled with four inches of moist sand and some pieces of shredded newspaper are scattered around. A screen is placed over the top of the container so that the insects will not jump out. About twenty to forty fully grown crickets are caught and all are placed inside the cage, half of which should be females; identified by the lance-like protrusion coming from the end of their abdomen. A water-filled pill bottle with cotton stuffed in its open end and placed on its side will provide a constant supply of drinking water for the insects. After about twenty or more days baby crickets will begin to appear and in approximately two months they will be fully mature.

When the temperature drops below seventy degrees a light bulb should be suspended inside the cage without providing too much heat. Because crickets and grasshoppers are actually clean animals, the cage should be cleaned frequently of uneaten food and fatalities. For an idea of how many insects to expect, the female cricket lays 150 to 500 eggs in one or two months. For more information on crickets look on page 197 of THE SURVIVOR in the Chamber's Encyclopedia.

Now for the last (and for some the fun) part of preparing insects as animal feed: once you have what you need the insects must then be killed without poisons or insecticides for obvious reasons. The other alternative is to drown them in hot water, though for beetles this takes some time, as this species dies hard. You can place the insects in a wire cage or a cloth bag and then submerge them in a sink or bucket of hot water. For moths, butterflies, or other large insects a pinch between the thumb and finger can be applied to the thorax (the segment behind the head). Sometimes this takes practice but its advantage is that is kills the insect instantly. Its disadvantage, however, is that it takes a brave—or foolish—person to use this method on bees or wasps. Aside from crushing the insect to a disgusting pulp, these are the only two procedures which can be applied.

Using insects to feed your livestock can be profitable and will leave you with more food for yourself, your family, or your survival group.



ASPIRATOR

Unarmed Combat [Combato]

by Bradley J. Steiner

Cont. from Vol. 1, page 131

Last lesson we discussed the basic low side kick, applicable to any sort of frontal oncoming attack, except the sort where the enemy is armed with a firearm. You also larned basic front choke-hold counters, and I touched upon some rudiments of serious personal defense.

Sparring is woefully inappropriate as preparation for actual hand-to-hand combat. There are many reasons why this is so, but I want to mention just one, for now:

The high kicks, the leaping jumps, the spinning, wheeling and acrobatic lunging techniques you see in the kung fu flicks (and at martial arts demonstrations) are strictly for "show" and for exercise—and I don't care what the black belt "experts" say. Ask some fancy high kicker what he'll do in an elevator, on a stairway, in a hallway, on an icy street or in a crowded store, etc. when trouble starts. Ask him if he'll start his showy moves when some junkie cut-throat is slashing at his neck with a razor. Or, will he simply GO IN, and rip and tear and punch and claw for the VITAL ZONES? I think we both know the answer. Anyway, for unarmed self-defense, forget the fancy stuff. Remember that a fight starts fast and close, and that if you intend to win it, you'd better get it over with before 20 or 30 seconds' time passes.

I'm going to stress three things this month—

ELBOW STRIKES
KNEE KICKS
HEAD SMASHES

—all close-in weapons, intended for use in a serious fight where you can't afford to fight fair.

Even a small man, or woman, can deliver powerful elbow, knee and head smashes, with a little practice. Using a heavy bag for strengthening one's blows is a good idea, but it's not 100% necessary. Remember that VITAL ADRENALIN FLOW will automatically speed up when your life is threatened, and you'll be both immune to less-than-fatal injury, and quite capable of delivering sufficiently strong blows with the "natural" weapons you've got.

Don't wait until your enemy is in the process of landing his sixth blow before you go into action. People, just like animals, have a "sense" for danger. When your SENSE tells you that physical assault is immediate: HIT FAST, HIT HARD, and HIT FIRST!!! Give no man an even break in a fight! Never hold back, and GIVE NO QUARTER, once violence is upon you.

KNEE BLOWS

It helps to seize the opponent's shoulders and pull him toward you as you kick. Drive your knee up AS HARD AS POSSIBLE, AND REPEATEDLY, into his testicles. Keep kicking until he collapses. You can apply this counter when a man grabs your lapel and yanks you in towards him. If a close-in choke hold is taken about your throat, this knee blow is also appropriate. Any encumbering, under or over-arm body hold provides you (if the opponent grabs from the front) with a perfect set-up for the knee blow.

Alternative to the knee blow administered to the groin, the FACE makes a dandy spot for a nice, vigorous knee kick. This is the sweetest answer to a front dive and tackle attempt. It can be applied even when the opponent is

standing in front of you, erect. Just grab his hair or ears or head, and knee his groin. Then yank him forward and down, HARD, as you push his face down into your knee kick. Kick twice, just to be sure.

ELBOW BLOWS

Keep the fist very tight, and bend the arm fully. Swing the elbow HARD, exactly as illustrated. Whenever possible, try to execute your blows against an opponent AS HE COMES IN TOWARD YOU. This magnifies and doubles the strength of your blow. Elbows make strong, vicious surprise weapons, and can deliver blows much harder than you'd probably realize. Practice is essential, though. Get "fluid" with fast, accurate elbow smashes.

HEAD SMASHES

Get into the habit of butting the nose of your antagonist with your head. It won't hurt you a bit, but it will provide a super opportunity to gain "clearance" for throat attacks, kicks, etc. Use whenever the enemy grabs in close, especially when he pins your arms from behind in a bear hug. Snap the head back HARD.

Girls should greet an unwelcome "Romeo" by first PRETENDING TO WARM-UP TO HIS ADVANCES, AND SMILING AS THEY "PUCKER" FOR A KISS. Suddenly, WHAMMO! Bash the bastard's nose hard, and drive knee to groin. Most persuasive.

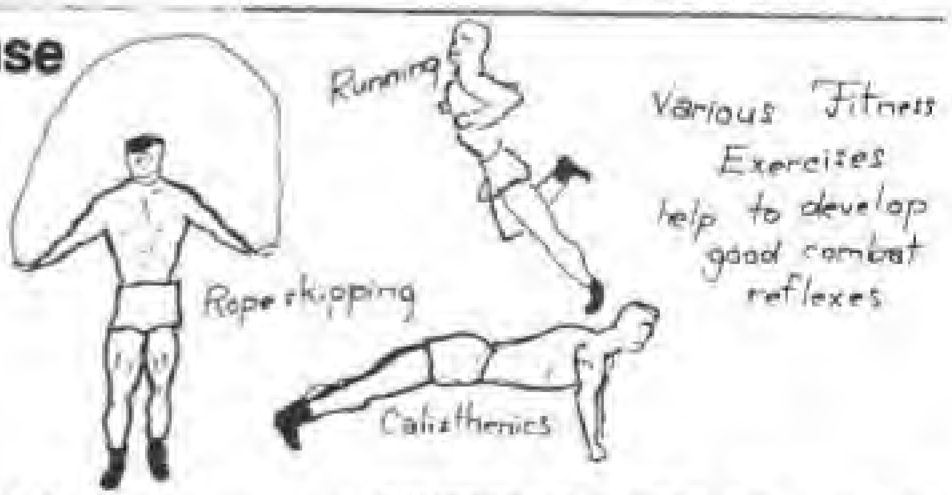
Well, I've left you with some nice games to play until next issue. Be careful in practice, puh-leeze. I accept no responsibility for injuries or accidents you or your partners (or your attackers) incur.

One last thought, before I sign off for this issue: YELL LIKE A MADMAN WHENEVER YOU DEFEND OR ATTACK. Grimace, shout, turn savage! That's the way to WIN. And WINNING's what unarmed combat is all about.

Reflex-Building for Self Defense

(How to reduce your reaction-time for personal defense situations)

By Bradley J. Steiner



Knowing what exactly must be done to meet and deal effectively with a physical assailant is one part of the answer to having an EFFICIENT response ready in your personal defense repertoire. HAVING THAT RESPONSE UNDER PERFECT CONTROL, TO THE EXTENT THAT IT CAN BE "TRIGGERED" INSTANTLY -- at your opponent's attack--is the other part of the answer. If your reflexive-response to an attack is slow, then it might just as well not be made; for it will begin long after the opposition's attack has "landed"!

One major purpose of my self-defense system, Combato, is to SIMPLIFY, to the greatest extent possible, the TYPES OF RESPONSES one trains with, so that the time required in the learning process to become proficient is reduced considerably. This is also why I am opposed to sparring and competition. These aspects of practice only increase one's GENERAL ABILITY TO TRADE BLOWS WITH ONE WHO FIGHTS IN THE SAME, PRE-DESIGNED MANNER AS ONESELF, ACCORDING TO THE "RULES" THAT HAVE BEEN DRAWN UP BEFORE THE CONTEST OR MATCH. The important thing is to DEAL WITH THE ACTUAL SITUATIONS, work out the best responses, then "internalize" those responses, so that they come into play with lightning rapidity when they are needed. This means DRILL. It means repetition of technique, until the stage is reached where an opponent's onslaught will "trigger"-- WITHOUT YOUR EVEN BEING

AWARE OF IT!-- the appropriate response.

In past articles I have dealt with certain basic personal defense ("Combato") applications. In future articles and books, I will deal with many more, in addition to training suggestions, body-development skills, etc. For now, I want to explain how you, the Survivor, can condition yourself and hone your reflexes to a razor's edge; so that whatever techniques we've so far discussed, can truly become "your own"--i.e. become "internalized" and imbedded within your subconscious mind. Once this is accomplished, you will react IMMEDIATELY and CORRECTLY to whatever sudden attack your opponent thrusts upon you.

THE GROUND-RULES OF TRAINING

The following are the general all-encompassing "basics" that apply to techniques of combat I've covered in past issues of THE SURVIVOR, and to techniques and combinations that will be covered in future issues.

1. KEEP YOUR OVERALL LEVEL OF PHYSICAL CONDITION HIGH; TAKE CARE TO GET AND STAY IN GOOD SHAPE-strong, fast and flexible.

The shape you're in enables your body to DO what your mind LEARNS. It is a glorious myth that strength and condition don't matter in the martial arts! Don't believe it, brothers! Armchair self-defense experts often end up in wheelchairs. Or worse!

I wrote a book on physical conditioning specifically for combat and survival ("FIT TO FIGHT! COMBAT CONDITIONING FOR PERSONAL DEFENSE AND SELF-SURVIVAL!") Paladin Press, P.O.Box 1307 Boulder, CO 80302 should have this manual available within a few months. Meanwhile, do everything you can to get in shape-and stay that way! No serious student of defensive skills or even survival can afford to neglect basic fitness. Mike Brown's articles on budget equipment and fundamental fitness training are great. They're as good an introduction to PRACTICAL and SIMPLIFIED physical training as you'll find. In addition to Brown's work, let me urge that you: Learn to jump rope, and then do so, for about 5 minutes every day. Do push-ups, leg-ups, sit-ups and some chinning, as well as jogging, or even running in place.

Being in good all-round shape permits personal defense skills to be learned more easily, applied more effectively and "remembered" by your nervous system more surely.

2. BE VERY CAREFUL TO SPEND YOUR TIME LEARNING ONLY SIMPLE, PRACTICAL TECHNIQUES.

This is not merely a plug for my COMBATO. It is a warning that could save your life. DON'T, if you are purely defense and survival oriented, involve yourself with complex, "showy" skills. These detract from your focus on the practical, simpler methods, and they SLOW reaction time, by giving you an ASSORTMENT of maneuvers from which your brain will be obliged to "choose" in a critical emergency. Keep things simple-simple-SIMPLE! Get those few fundamental moves that ALWAYS WORK, and drill them. Drill them until they're coming out of your ears!

In these articles in THE SURVIVOR, I will enumerate, over a period of time, a wide variety of effective, simple, proven defense skills. These moves will lack the beauty and grace of, say, classical Aikido or Karate; and they will lack the finesse, possible, of many widely-taught jiu-jitsu techniques; YET THESE ARE THE SIMPLE MOVES YOU NEED WHEN YOUR LIFE IS ON THE LINE. I urge you again: KEEP THINGS SIMPLE. Unless you are in the martial arts for sport and play, DO NOT clog up your mind and reflexes with a quantity of "pretty" but nonetheless questionable moves. By narrowing down on, say, two and only two simple choke defenses, you can DRILL these to the point where they will become SO FAST, SO STRONG, SO EFFICIENT and SO ACCURATE, that they will be virtually 100% guaranteed to work. Any opponent thus assailing you, will be triggering his own demise! His attack will serve as the ignition spark that sets into blindingly-fast action your pre-drilled defense combination. Every attack against you will become the first step of the would-be attacker's destruction!

3. PRACTICE THE ACTUAL PHYSICAL TECHNIQUES-EVEN IF YOU MUST DO SO ALONE, WITHOUT A PRACTICE PARTNER.

The art of Karate has an aspect of training that is as poorly understood today, as it is widely practiced: KATA. We hear instructors and students say that Kata is "essential because it is traditional". We hear others say that it is "unnecessary because it is senseless and primitive". And so on. The truth is that KATA, when properly studied, is the surest way to develop potent unarmed combat skills. The reflex-building and training of the mind and nervous system for combat in Kata is simply fantastic.

Kata-practiced PROPERLY-enables the Karate student to IMBED both the reflexive/mental responses and the muscular/physical responses to all possible attacks DEEPLY IN HIS "BEING". The catch of course is that traditional Kata requires many, many months or even years of study, before it produces the desired results. This is because it covers HUNDREDS, even THOUSANDS of techniques, and must be reviewed and drilled DAILY, for success in actual combat to be the result of training.

Today, in Combato, what I do is use a form of MODIFIED or SIMPLIFIED KATA that narrows down and very simply deals with select, necessary defenses. The exact same movements are either drilled with a practice partner (cautiously) or by oneself. PROVIDING YOUR MENTAL STATE IS CORRECT, you will be preparing yourself perfectly for the "real thing". What is important is to fully understand the physical techniques movements and then PUT YOUR BODY THROUGH THOSE MOVEMENTS, REGULARLY.

While going through the techniques it is necessary, especially when practicing alone, to VISUALIZE AND VIVIDLY IMAGINE THAT YOU ARE ACTUALLY UNDER ATTACK. This means that practice must be, and also must not be, mechanical repetition. It must be repetition, in the sense that practice must be DRILL; but it must not be "mechanical", in the sense that repetition of technique without "feeling" and without "emotional immersion" cannot "take". Only practice that VIVIDLY CONDITIONS YOU, AND PUTS YOU THROUGH THE EXPERIENCE, SO TO SPEAK, can prepare and train you.

4. WHEN YOU PRACTICE IMAGINE THAT IT IS "THE REAL THING", AND WHEN YOU ARE NOT PHYSICALLY PRACTICING, IMAGINE YOUR SITUATIONAL RESPONSES AND COMBAT TECHNIQUES. The human nervous system is both strange and wonderful. Believe it or not, the vivid IMAGINING of an event can produce within one the conviction (within the nervous system) that one has "experienced" that event. Thus, if you sit down quietly in a chair, every day for five minutes, and concentrate hard on imagining, say, your defense maneuver against a frontal choke hold, and ACTUALLY SEE AND FEEL your satisfactory, trained response to the attack, you will be doing something just about as effective as actually practicing the technique! I say "just about" as effective, because unless you do something other than imagining to keep your body fit and strong and flexible, you'll not possess the CAPABILITY of doing the defense maneuver under fighting conditions-even though you might well "know" it perfectly.

The more your mind's eye SEES you going through the right defensive tactic, the more that defensive tactic will imbed itself in your mind and nervous system. Keep programming yourself, regularly, patiently and, of course, WITH THE MOST EFFECTIVE TECHNIQUES, and sure enough, your reaction-time will reduce itself to a hair's breadth! You will in not too long a period discover that an aggressive approach from anyone under any circumstances AUTOMATICALLY, without your having to "think things through", brings your physical and mental powers into efficient defensive play.

In essence, what I'm speaking of here is my modernized or "updated" version of the mental state inherent in Karate KATA performance.

ANOTHER ASPECT OF THE PROBLEM

There is another aspect of the problem of building fast defensive reflexes. It is this:

Too many basically decent people have, what I call, a "stop-brake" within their minds that automatically "prevents" them from taking IMMEDIATE aggressive, violent action. This, ironically, is the penalty a decent person pays for not having the psyche of a criminal or thug!

You see, violent criminals are conditioned to act/feel or think and decent people are conditioned to think or feel/act; so there's a problem in self-taught reaction-timing. A punk or a thug looks at you, then mashes your face in. You, on the other hand, unless you've been correctly self-conditioned, look at and see the thug, then YOU REQUIRE A MOMENT OR TWO TO "REASON OUT" THAT, INDEED, THIS CREATURE "DESERVES" ROUGH TREATMENT, BEFORE YOU KICK HIS CROTCH IN. All very, very noble of you, I'm sure; but potentially a fatal policy, I'm afraid!

Reaction on your part to aggressiveness must be INSTANT VIOLENT COUNTERATTACK! Nothing less, nothing slower, nothing but IMMEDIATE, VIOLENT COUNTERATTACK.

There is no way to achieve this "change in your psyche" unless you will devote some attention to cultivating a NEW thought pattern, regarding violence and violent threats. Learn to distinguish between PEOPLE and violent CRIMINALS. People deserve, it is true, careful and thoughtful responses, based in part upon your considerations of justice, ethics and fairness. Violent aggressors DO NOT! There is a difference.

IN LEARNING TO BE COMBAT-READY, THE SURVIVOR MUST LEARN TO BYPASS THE THOUGHT-PROCESS WHEN HE DEALS WITH THOSE WHO, THEMSELVES, REFUSE TO THINK. THE SURVIVOR STUDYING SELF-DEFENSE LEARNS THAT THERE IS NO OBLIGATION WHATEVER UPON HIM TO BE "REASONABLE", "JUST", "ETHICAL" OR "FAIR", WHEN HE IS DEALING WITH THE SCUM-ELEMENT WE KNOW AS THE VIOLENT CRIMINAL.

Hesitation is a great retarder of proper reflex response. If you wish to learn effective personal defense, learn-if you are attacked-NOT to hesitate. Go right into action-at once! Immediately! No delay!

Practice, so long as you are convinced that it is incumbent upon you to be fair, will do little to decrease your reaction time. Until you have settled, once and for all time, the question of "should you or shouldn't you go all-out, and do so at once" in the face of violent attack, you are working at awfully-reduced efficiency.

Some years ago, in New York, a tournament-winning black belt karate practitioner was knifed to death while riding home from a date, on the subway. Why? Not, certainly, because he lacked the knowledge of what techniques he should have used to protect himself. He died at the hands of two scummy misfit animals BECAUSE HE GRANTED THEM THE SAME TERMS OF CONDUCT HE WOULD HAVE GRANTED A NORMAL HUMAN BEING: HE TRIED TO TALK REASONABLY TO HIS ASSAILANTS WHEN THEIR INTENTIONS WERE INEVITABLY APPARENT.

The youth, a fellow named Ramirez, tried to REASON with the two varmints who sat beside him on the train and threatened him, while they demanded money. Witnesses said that the young black belt NEVER EVEN MADE AN ATTEMPT TO FIGHT BACK-even when the chance to do so was glaringly open to him.

HESITATION. THE ERROR; thinking that what is appropriate with one's neighbors is appropriate with violent, human (or I should say, sub-human) pestilence. Had Ramirez responded to the demand for his money by rising from his seat and kicking in the face of one of his assailants, as he ripped out the eyes of the other, he would probably be alive today; and there would be two less ounces of scum-rot inhabiting New York and cluttering up her streets.

Ramirez had been trained to SPAR, to COMPETE; not to fight—not to SURVIVE!

Once, a student of mine (a young girl of about 14 or so) was walking home from school, when she was accosted by some stump of rot. He stepped in front of her and reached to take her arm. Two seconds later she was grinding her heel into the side of his face. She didn't HESITATE. She didn't STOP TO DECIDE. When the threat came, she RESPONDED I N S T A N T L Y!!

There is nothing spectacular about basic personal defense-COMBATO. It is simple, based upon simple techniques, applied vigorously, with not a second's delay between the materialization of the attack, and the materialization of your defense. The two are one: like, to use a classic Oriental illustration-Yin Yang. One follows inevitably into the other, even as the other comes into being. With one, there is the other. When the aggressor's attack becomes a reality, your defensive combination is there at once you cope with it.

The development of the true fighter's

Repetition of Basic Techniques Vs Imaginary Attacker Helps Develop Speedy Reflexes!

Elbow strike counter follows break of front choke

Head of "assailant" is seized and jerked forward, and knee kick follows to "face" — ALL IN THE MIND!

reflex-reactions is NOT beyond your grasp. It is possible to you, and it will provide you with the self-confidence and security you need-IF you take the trouble to work for it. I assure you, it is worth you while.

Get and stay in good shape. Narrow down your technique-repertoire, to include only the best and simplest techniques. Practice-practice-practice those few, simple techniques. Use vivid imagination and concentration to prepare mentally and to program your nervous system and, finally, work toward the development of a rational, self-serving survival philosophy that encourages you to differentiate between humans and scum, and, most important to ACT accordingly. In the face of aggression, this means to act INSTANTLY!

Do your best to assimilate the message in this article. I would not have written it if I did not know that it was crucially important to every survival-conscious individual. In issues of THE SURVIVOR to come I will elaborate upon many, many good battle-proven techniques. If you really learn to apply what I've said here, those techniques will inevitably become an effective addition to your "survival repertoire".

INVISIBLE INK

Ammonium chloride, "sal ammoniac", dissolved in 15 to 20 times its weight of water makes an ink that is invisible, but becomes dark brown or black when pressed with a hot iron, or held at a distance above a small flame. This is as good a sympathetic ink as any, is easy to prepare, and is not dangerously poisonous.

The salts of several metals have long been favorite materials for sympathetic ink. These salts are not all colorless when in the solid form, or in strong solution, but invisible marks made on paper with very dilute solutions can be developed by suitable means. Among these salts are lead acetate, ferric sulphate, mercuric chloride (corrosive sublimate, dangerous to handle and very poisonous), copper sulphate, cobalt chloride, and nickel chloride. In addition to being turned brown or black by the fumes of ammonium sulphide, writing with any of the salts can be developed by heat, and still other means can be employed with some of them. For instance, if the ink is made with ferric sulphate, a solution of gallic or tannic acid will turn the writing black, and potassium ferrocyanide will form prussian blue.

Of the salts just mentioned, cobalt chloride is in some respects the most interesting. When a solution of the salt in water evaporates to dryness, the chloride appears in crystals that are red, though not intensely so. If the solution used as sympathetic ink is so dilute as to be only of a moderately deep pink, the thin layer of the salt that is left on paper when the writing dries will not be perceptible. If the writing is kept for some time in rather dry air, or is warmed slightly, the cobalt chloride loses most of its "water of crystallization", and is then so intensely blue that the writing is visible. Exposure to moist air, as by breathing upon it, makes the writing vanish because the blue salt regains water of crystallization and turns red. These changes back and forth can be repeated many times, but if once the secret writing should be heated too strongly when warming it, the chloride will char the paper, and the writing will then be permanently black.

As a means of developing writing done with a variety of inks, iodine is interesting. It is preferably used as the vapor given off by the solid element at ordinary temperatures, though the tincture diluted with water can be employed. If a thin solution of boiled starch is used for the writing, iodine will turn it blue. The color disappears after a time, and more quickly by gentle warming. Writing with a solution of soap becomes yellow or brown because the soap absorbs iodine vapor more easily than paper does. This color soon vanishes because the iodine is so volatile. Copper sulphate and lead acetate are colored temporarily, while marks made with mercuric chloride show as white on a background of yellow paper. If the writing is done with distilled water, iodine vapor will color the letters a little more strongly than the background. The water disturbs the sizing at the surface of the paper, and thus allows the iodine vapor to be absorbed more readily there than elsewhere.

Another type is as follows:

Water	640 cc.
Acetone	350 cc.
Phenolphthalein	4 g.
Caustic Potash	1 g.

Writing with this ink is made visible by ammonia.

How to Make Disappearing Ink

A writing fluid that will disappear and can be caused to reappear when desired can be made as follows: Mix linseed oil, 30 drops, ammonia, 1 fluid oz., and water, 5 fluid oz. To make the writing appear when this ink is used, dip the paper in water. As soon as the paper dries the ink will disappear again.

KNOW YOUR ENEMY

By Martin Donnelly

In an old war that happened once, the generals and their staff psychologists used to tell us that we needed to understand the motives of our opponent. This was just great, except that we never got to know him until the jungle growth parted and there he was with his bayonet already only inches from our chests. Many of us, on ships and in aircraft, never even so much as saw him at all.

Unhappily, something of the same sort may take place in a survival situation, if in a different way. Here the enemy may be all around us, and we won't recognize him even when face to face.

There are, however, some standards for judgment though they may be far from infallible.

One psychological characteristic of an enemy of society is an exclusive devotion to self. Call it self-centeredness. Such a man is often amoral, that is, congenitally lacking in any consciousness of moral responsibility. This type may be hard to spot. But there are symptoms. He will be reluctant to cooperate with others in a survival group, unless there is direct and immediate benefit to him. He will tend to hoard his own personal resources, not share. Perhaps only in little ways, but detectibly, he will take rather than give.

Beyond the amoral man is the true psychopath. Here is a clinically disordered personality. He literally does not know the difference between right and wrong. Such a man is extremely dangerous, for the very reason that his motivation is so simple. He goes straight toward his objective--his own self preservation--because he is incapable of thinking of anything else. And, by the way, this man may be very good at survival, again as a result of concentration upon self.

Now, it's one thing to judge a member of a group, who can be observed. But what if you meet a stranger? You do not know this man, and have no way of judging him. Here your only recourse is to be open and friendly, but guarded. Open and friendly, so as not to arouse suspicion on his part by showing suspicion on yours; remember that he will be judging you too. Guarded, so as not to leave yourself open to exploitation.

There is no easy answer to the question of the stranger. In a survival situation we need each other, we have to trust. We can only try to avoid trusting blindly.

To further complicate matters, there is yet another consideration. We have spoken here of other members of a group, and of the stranger, as possible enemies. But the true enemy may be within yourself.

Here is the most difficult problem of all. For to know one's self is very hard indeed. Self examination takes great moral courage. Yet we all of us have faults that should be taken out of the dark recesses of our minds and looked at. The ability to withstand stress varies greatly between individuals, and depends upon just what sort of stress it is.

One example occurred during a military arctic indoctrination exercise. A member of the group suffered secretly from claustrophobia, the fear of confined spaces, but thought he could handle it so told no one. He came awake from a dream at night, alone in a cramped snow shelter he had built as part of the drill, and in a sleeping bag that had a sticking zipper. The sudden feeling of intolerable confinement panicked him; he tore the zipper apart with his fingernails and ran blindly out onto the ice of the Bering Sea. His action endangered others and nearly cost him his life.

It's no disgrace to acknowledge a personal problem. Most of us are good at one thing, not so good at another. The thing is, we need to accept and to give help. And to try to anticipate, for good or bad, what we may expect from one another.

None of this is to say that you should be looking over your shoulder all the time, fearful of others. Nor need you be too introspective and fearful of yourself. True that in our civilization we have become too interdependent, and that survival requires self-reliance and an attitude of watchfulness. But it also mandates cooperation, between individuals and groups. Most people, in the final analysis, will recognize that they must help each other.

We need only to learn and understand the frailities of human nature, including our own. To know our enemy, whether without or within, so that we may all survive.

OINTMENT FORMULA

by Stan Anderson

It is well to know how to prepare a good ointment which may be used for many things from boils to burns. When one prepares such an ointment, one may be assured as to the actual contents and if it is made with various herbs there is little chance of the harmful side effects of some of the commercial preparations that are on the market today. Besides this, there is the satisfaction of gaining some worth while do-it-yourself knowledge as well as the joy of productive work.

For best results it is well to communicate with the spirit of the plant, tell it what you plan to use the ointment for and thereby gain its blessing upon the project. It has been found that more beneficial results from the ointment will be had if this procedure is followed first.

For the majority of ointments the following plan is suggested as it has produced good results for all who have tried it.

Place into a double boiler pan one and a half pounds of lard (preferably beef lard as it has good drawing properties) add two ounces of bee's wax and place the pan into the oven at between 180 and 225 degrees until the lard and bee's wax is melted. The lower the temperature used to melt the wax and lard the better. Make sure that the pan is stainless steel, earthenware, unchipped enamel or glassware as certain metals will precipitate toxic materials into the ointment.

To the melted lard and wax add a pound of fresh or one half pound of the dried herb or combination of herbs that you desire to use. You will know when you have enough herbs by pressing them down firmly so that the liquid barely covers them. Place the pan back into the oven at the same temperature for three to four hours. After the first half hour press the herbs back into the liquid so that they remain covered. After three hours lift the herbs with a fork to see if they are getting brown and brittle. When this happens the lard as a catalyst has drawn the value out of the herbs and they may be removed.

Strain off the liquid into a measuring cup and pour such liquid into small wide mouthed bottles to cool. In warm climates more bee's wax may be added so that the ointment does not re-liquify. When no more liquid can be poured from the mixture, place the herbs into a potato ricer or wrap them in a clean white sheet and squeeze them in order to extract the rest of the liquid. In the event that some of the ointment hardens on various utensils they may be placed in a pan and replaced in the oven to re-liquify so as to not have any waste.

Label the jars as to the contents and proper usage and place a couple pieces of scotch tape over the labels so that they will not come off.

Ointments are for external use, use no more than is necessary unless it is covered so that the grease does not rub off.

One combination of herbs which has proved to be quite effective in many situations is Comfrey, Plantain, Golden Seal Root powder and Myrr. Using the above method, fill the pan with half Comfrey leaves and half Plantain leaves, add two heaping tablespoons of Golden Seal root powder and two heaping tablespoons of Myrr powder.

The Plantain and lard have a drawing effect, the Comfrey sooths and heals, while the Golden Seal and Myrr also heals as well as produces an antiseptic effect. This ointment has proved to be effective in burns, cuts, boils and absesses, blood poisoning, poisonous bites and stings, itching, infected wounds, rashes and external ulcers.

Good luck on your ointment preparations and don't forget to include a jar of the above multipurpose ointment in your survival pack.

A New Survival Gun

by Martin Donnelly

Before we get into any arguments here, almost any kind of weapon can be a survival gun and we all know it. If I were pressed, the 300 year old wheelock in my collection would do. Or we can, any of us, roll our own, given a length of metal tubing and some wood and wire and a handful of matches. Also true.

But let's be reasonable. I'm not going to walk around with a thermonuclear missile slung over my sholder, and neither are you, although it would be handy if we are to survive against man. But if we're talking about survival against nature, with an emergency capability against man, then the problem gets cut down to size. We need a gun that is light in weight, easy to pack, durable, and effective. Within the limitations these criteria inexorably impose.

The true survival weapon is a product of the air age. It came into being because airmen needed a compact weapon that could be carried in emergency packs during flights over unfriendly terrain. One of the best of these is the still current "Explorer" Model AR-7, in its civilian version, made by Charter Arms. This is a magnificant survival arm. It's a semi-automatic .22 Long Rifle, weighs only two and a half pounds, takes down so that its barrel and action can be stored in its hollow stock, and it floats. With this rifle I can fire a two-inch group offhand at fifty feet, and I'm no expert shot. I can't fault this gun in any way, as a survival weapon.

However, times change. Something new has come on the scene just recently. This is the Garcia "Bronco" 22/410 over and under, distributed by FI Industries of Washington, D.C. This combination gun is all metal, with a skeltonized stock and pistol grip, and a unique rotate-open action. It isn't pretty. But it's rugged, simple, and inexpensive. And it shoots.

It'll get you a one-inch group from rest.

with the rifle barrel, at twenty five yards. The shotgun barrel will pattern a good 50% at thirty yards with 7½ shot. This is shooting.

The gun takes down, almost instantly with a twist of the wrist. The package measures twenty inches. It weighs 4½ pounds. The action opens by rotating or twisting the paired barrels to the left, a method so simple that it makes nonsense of claims that an over/under action absolutely must be enormously complicated and expensive. The weapon is all steel, and has a near-rustproof black crackle finish.

It might be argued that the Bronco over/under is so much of a compromise, with its limited two-shot capability and diminutive calibers, that there's not much left to go with. I wouldn't take it out for elephants myself, nor would I feel exactly confident about its man-stopping effect against an enraged Phillipine Moro tribesman. But it'll get you a lot of small game. And there aren't that many Moro tribesmen around these days; I think that your average aggressor, if he has sense enough to be walking around by himself, will not like the thought of a .22 LR hollowpoint in his chest cavity and a .410 shotload in his belly.

SODIUM CHLORATE FROM SOLIDOX

By David Metz

With potassium chlorate both difficult and expensive to obtain, I set about looking for ways in which the survivalist could produce his own supply. So far, that line of experiments has not worked. Instead I have discovered a cheap easy source of sodium chlorate.

Sodium chlorate and the more familiar potassium chlorate are chemically almost the same. Both contain the chlorate ion, a combination of the gas chlorine with the gas oxygen. The oxygen is the important part. The difference is that the atom of potassium metal has been replaced with an atom of sodium metal. Since both metals have some similarities the two chemicals are very much the same.

There are some differences; I'll cover these later.

Our cheap source of sodium chlorate is Solidox pellets. These are sold in hardware stores for three to four dollars a two pound can. Solidox is used as a source of oxygen gas for a small portable welding set.

The Solidox pellet is about 1"x4" and is black in color. They are made in slightly different formulas to provide oxygen at different rates to suit the different setting of the welder. The oxygen gas is produced by burning the pellets in a special cannister.

The formula of the pellet appears to be 80% sodium chlorate, to provide the oxygen. The rest is glass fiber to hold the burning pellet together and black powder that appears to be a mixture of powdered charcoal and manganese dioxide. The charcoal serves as the fuel to burn the pellet and the manganese dioxide acts as a catalyst to increase the amount of oxygen released.

Our job is to extract the useful chlorate from the rest fo the mixture. Luckily for us the waste materials are all insoluble in water. The desired chlorate is very soluble in water.

The first step is to break up the pellets so they will dissolve easily. Break up the pellets inside the bag they come in. Avoid breathing the dust as sodium chlorate is toxic.

Dissolve the now powdered Solidox in hot water. Start with about two quarts. Stir the mixture well to dissolve as much of the chlorate as possible.

Next prepare the filter. I used a large funnel made of plastic. The funnel is supported with a wire hoop over a kettle. The filter material is ordinary cheap paper towelling. Pick the kind that does not have holes in it and use two layers.

While your Solidox solution has been sitting in its container, most of the waste material will have settled to the bottom. Pour the liquid through the filter funnel. The resulting liquid should be clear. If it's not, filter it again.

Dump the black glop from the filter into the container with the other undissolved waste material. As before, let it settle after you have added some hot water to it. This time just use a pint. Then filter as before. This last step insures that all of the chlorate has been dissolved.

At this point, discard all of the waste materials. If your separated chlorate solution is still cloudy, filter it again.

There are two ways to remove the water from your chlorate solution. Since moderate heat will not break down the chlorate, the fast way is to boil the solution until a thick paste is left. Then spread this paste on paper towels to dry out the last of the water.

The other way is to evaporate the water. Place the solution in a shallow pan in the sun. If the pan is dark colored it will absorb more heat and the drying process will be faster. Note that the chlorate solution is corrosive like most salts. Use plastic or other lined containers that do not rust easily.

If you were careful you should now have a little over 1½ pounds of sodium chlorate for your troubles. And at a price of less than $2.00 per pound.

Here are the differences between the two chlorates. First, sodium chlorate is TOXIC. It is used for killing weeds. Be careful, do not get it on the skin or ingest it. Unlike potassium chlorate, the sodium compound will readily absorb water. Thus anything holding it must be carefully water-proofed. When sodium chlorate is used in pyrotechnics it burns with an intense yellow-orange flame.

Note that when sodium chlorate burns it releases its oxygen and becomes ordinary table salt. Expect it to be very corrosive if used in primers and propellants.

Like potassium chlorate, the sodium compound can be used in igniters. It works perfectly in sugar/sulfuric acid system igniters. It can also be used mixed with sulfer to make percussion caps. Note that not all formulas may work with the sodium chlorate substitute. Sodium is not as reactive as potassium.

The possibility exists that a simple exchange reaction will convert sodium into potassium chlorate. If I can make this work, I will report it in a later article. LAST SAFETY NOTE: When evaporating any chemical solution, do not boil it to dryness. Impurities present could cause a fire or explosion.

Leather Leash on Hammer Keeps It Always Handy

WHEN doing a carpentry job, what could be more handy than to have the hammer attached to your wrist with a leather leash, as shown in the accompanying drawing. When not in use the hammer swings from the wrist, leaving both hands free. A downward scoop of the thumb replaces it in the hand. Any piece of heavy leather or cord will do the job.—

Homemade Cut Press
From Popular Mechanics 1915

The person who has a little ability in making wood cuts with a knife will find it very interesting to make the press shown in the sketch. A fair job of printing can be done with the press, using printer's ink spread on a piece of glass with a hand ink roller, such as can be purchased cheaply of any dealer in printing supplies.

The press may have a base, A, of any size to suit, but one 1½ in. thick, 6 in. wide, and 12 in. long will be found to serve best for most purposes. It must be smooth and level. Hard wood, such as maple, beech, or birch, is best for all parts. The post B is 1¼ in. thick, 2 in. wide, and 5 in. long. Before setting it, slot the upper end for the end of the lever. This is done by making a saw cut, 1¾ in. deep, ⅝ in. from either side and cutting out the core to make a slot ¾ in. wide. A ¼-in. hole is then bored through the prongs to receive a stove bolt that connects them with the lever. The post is fastened with screws and glue in a notch cut in the center of the base end.

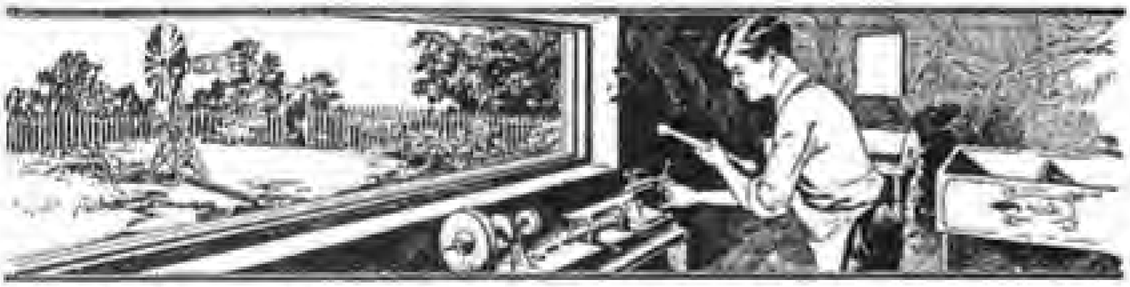
The lever C is made of a piece of wood ¼ in. square and 10 in. long. At the forward end the sides are pared away to form a tongue, or tenon, that will pass between the prongs of the upright, and a hole is bored through it to match those in the prongs. The entire upper surface of the lever is rounded and the under surface is rounded, beginning 6 in. from the tenon end. Glue to the under side of the lever a block, D, at the end of the under, flat surface. The block should be about 1¾ in. square by 1½ in. long. If the under side of the base is crowning,

A Hand Press for Printing from Cuts Made of Wood, Using Ordinary Printer's Ink

either level it with a plane or nail cleats across the ends for feet. A washer is used with the stove bolt in connecting the lever and post.

The cuts are made of small blocks of wood, about ¾ in. thick and of a size to take the characters desired. These blocks must be level and the printing side made smooth with very fine sandpaper, or a scraper, before the characters are laid out. Boxwood is best for cuts, but pearwood, applewood, birch, or maple will do very well. Mark out the characters backward, using the pencil very lightly. Then, with the small blade of a knife, made as sharp as possible, cut around the outlines, holding the knife slanting, and remove the adjacent wood by cutting in at a reverse angle to meet the boundary cut. Gradually deepen the cuts around the characters until they stand in relief about ⅛ in., then score V-shaped grooves, checkerboard fashion, across the remaining high surface that is not a part of the design, and chip out the resulting small blocks to bring the entire secondary surface of the block to a uniform level with the portions adjoining the characters.

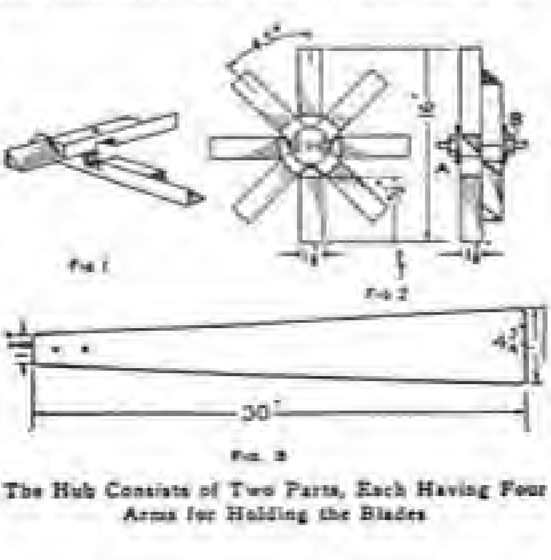
A touch of glue to the back of the cut will set it securely enough to the bottom of the block D for printing, and allow its removal without injury when desired. To get a uniform impression in printing, place paper on the base, as at E, to the thickness required. For controlling the printing position on the stock paper, pins or tacks can be stuck into the base and each sheet to be printed laid against these guides.—



A Power Windmill
From Popular Mechanics 1915

The windmill shown is somewhat different from the ordinary kind. It is not a toy, nor does it approach in size the ordinary farm windmill, but is a compromise between the two, and in a good strong wind, will supply power enough to run a washing machine, a small dynamo, an emery wheel, or any other device used in the home workshop. The wheel is about 5 ft. in diameter, with eight blades. The over-all length is about 6 feet.

The windmill is easily made and the cost is within the means of the average boy. There is not a part used in its construction that cannot be found about an ordinary manual-training shop. The most difficult parts of the construction will be described in

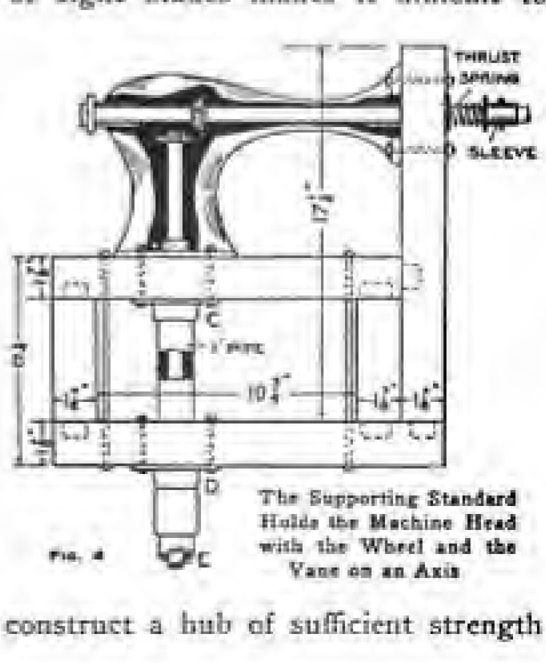


The Hub Consists of Two Parts, Each Having Four Arms for Holding the Blades

detail. Symmetry and smoothness of design should be preserved and the parts made as light as possible consistent with strength and durability.

The Wheel

As shown in the drawings, the wheel has eight blades. Ordinarily the use of eight blades makes it difficult to



The Supporting Standard Holds the Machine Head with the Wheel and the Vane on an Axis

construct a hub of sufficient strength

to carry them. Where so many blades radiate from a common center it is almost impossible to provide an anchorage for each blade. To provide a maximum of strength coupled with simplicity of design, the plan of using two hubs of four arms each was adopted in the construction of this mill. The ordinary hub of four arms is simple to make and quite strong. Four pieces of straight-grained oak, each 16 in. long and $1\frac{1}{8}$ in. square, are used in constructing the hubs. The manner of notching each pair of pieces together is shown in Fig. 1. The slope for the blades is made to run in opposite directions on the ends of each crosspiece. The slope is formed by cutting out a triangular piece, as shown.

The two hubs, thus formed, are mounted on the shaft, one behind the other, in such positions that the arms will be evenly divided for space in the wheel circle. These details are shown in Fig. 2. The blades, Fig. 3, are made of thin basswood or hard maple, and each is fastened in its place by means of two $\frac{3}{16}$-in. bolts, in addition to which a few brads are driven in to prevent the thin blades from warping.

The Gears

This windmill was designed to transmit power by means of shafts and gear wheels, rather than with cranks and reciprocating pump rods, such as are used on ordinary farm mills. To obtain this result, an old sewing machine head was used. Such a part can be obtained from a junk dealer or a sewing-machine agent. The head is stripped of its base plate with the shuttle gearing; likewise the needle rod, presser foot, etc., are taken from the front end of the head along with the faceplate. The horizontal shaft and gear wheel are taken out and the bearings reamed out for a $\frac{1}{2}$-in. shaft, which is substituted. The shaft should be 2 ft. in length, and 8 or 10 in. of its outer end threaded for the clamping nuts which hold the two hubs in place, as shown at A and B, Fig. 2. The gear wheel is also bored out and remounted on the new shaft.

The supporting standard is constructed of oak, with mortise-and-tenon joints, as shown in Fig. 4. The width of the pieces will depend on the kind of sewing-machine head used. It may be necessary also to slightly change the dimensions. The machine head is fastened on the support with bolts. A sleeve and thrust spring are mounted on the shaft, as shown. The sleeve is made of brass tubing, of a size to fit snugly on the shaft. A cotter will keep it in place. The sleeve serves as a collar for the thrust spring, which is placed between the sleeve and the standard. This arrangement acts as a buffer to take up the end thrust on the shaft caused by the varying pressure of the wind on the wheel.

The Vane

To keep the wheel facing the wind at all times, a vane must be provided. It is made of basswood or hard maple, as shown in Fig. 5. It is not built up solid, air spaces being left between the slats to reduce the wind resistance. Unless built in this manner, the vane is liable to twist off in a gale. The horizontal slats are $\frac{1}{4}$ in. thick, and the upright and cross braces $\frac{3}{8}$ in. thick, while the long arm connecting the vane to the supporting standard is $\frac{1}{2}$ in. thick.

The supporting standard, carrying the wheel and the vane, must revolve about a vertical axis with the changes in the wind, and this vertical axis is supplied in the form of a piece of gas pipe which runs through the supporting standard at the points marked C and D, Fig. 4. Ordinary pipe fittings, called flanges, are bolted to the frame at these points. The coupling in the gas pipe beneath the supporting standard serves as a stationary collar to support the weight of the whole mill. The vane should be placed correctly to balance the weight of the wheel.

The shaft passes through the framework of the mill on the inside of the pipe, as shown at E. A $\frac{3}{8}$-in. soft-steel or wrought-iron rod is satisfactory for the shaft, as no weight is supported by it and only a twisting force is transmitted. The use of a larger rod makes the mill cumbersome and unwieldy. The upper end of the shaft is fastened to the shaft that projects from the under side of the machine head by means of a sleeve made of a piece of $\frac{3}{8}$-in. pipe. Two cotters hold the shafts and sleeve together.

At the lower end of the shaft, inside the workshop, the device shown in Fig. 6 is installed. The purpose of this appliance is to provide a horizontal shaft upon which pulleys or driving gears may be mounted. The device is constructed of another sewing-machine head similar to the one already described. The head is cut in two and the separate parts mounted on suitable supports. The gap between the sawed portions permits a pulley to be fastened on the shaft to serve as the main drive. The wheel propelled by the treadle of the sewing machine will make a good drive wheel. The small handwheel, originally mounted on the machine-head shaft, is left intact. This arrangement gives two sizes of drive wheels. Heavy sewing-machine belts will serve to transmit the power.

The Tower

The tower can be built up in any manner to suit the conditions. Ordinarily sticks, 2 in. square, are suitable. These are well braced with wire and fastened securely to the roof of the shop. The arrangement of the tower with the mill is shown in Fig. 7.

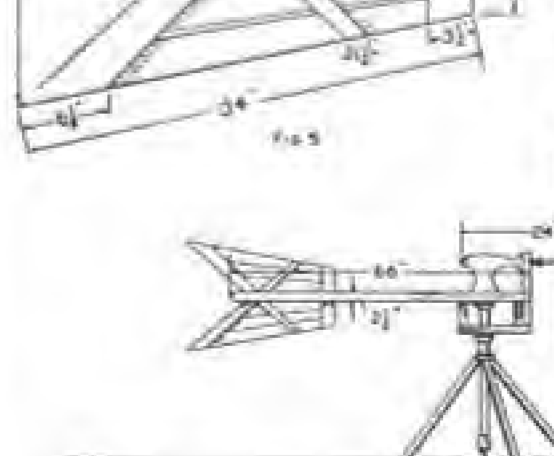


Fig 5

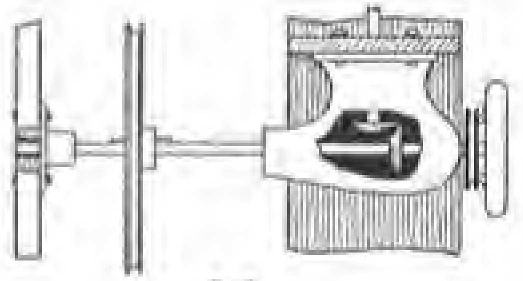


Fig 6

The Lower End of the Shaft has a Horizontal Shaft Geared to It for the Drive Pulleys. The Vane Construction and the Manner of Building the Tower on Which the Supporting Standard Revolves

Fig 7

waiting to bring them out at the next big political rally. At any rate, they can be made even more devastating with the addition of a few ounces of lead in the tip.

So there you have it, my friend—lathe-work can be an interesting and profitable hobby, or even a home business. Like anything else, you get out of it what you put into it.

Good luck on your new hobby or home business!

Books for further reading: Anderson, Edwin P. HOME WORKSHOP AND TOOL HANDY BOOK; Bower, Clifford Thomas THE BOOK OF THE LATHE; A PRACTICAL HANDBOOK FOR ALL CENTER LATHE USERS; Gustavsson, Ragnar CREATING IN WOOD WITH THE LATHE.

Put Your Garden in the Test Tube

...EASY EXPERIMENTS SHOW CHARACTER OF SOIL

From Popular Science 1937

By RAYMOND B. WAILES

HOW is your garden growing? If the plants appear sickly or underdeveloped, a horticulturist would look first for injurious insects. Then he would examine the soil to see whether it is the type that the plants need.

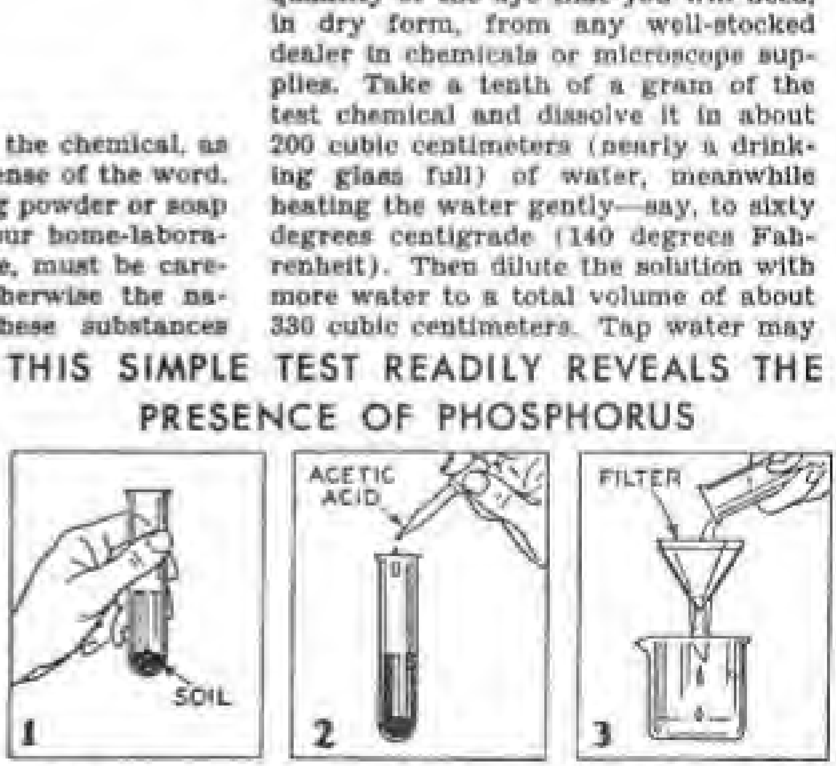
Perhaps the earth should be a little more acid, or alkaline. Possibly it needs more of certain plant foods such as phosphorus or nitrogen—for all kinds of house and garden plants, as well as shrubs, trees, and farm crops, have their own favorite kinds of soil. Plants die and crops fail, all too often, because the grower does not know their soil needs, or because no means of testing the soil is at hand.

However, any amateur chemist can readily test the soil of his own garden. Only the simplest of chemical equipment is required. Just one special precaution need be taken. Test tubes, testing plates, measuring devices, and even the experimenter's hands must be scrupulously clean—in the chemical, as well as the ordinary, sense of the word. Every trace of scouring powder or soap used in washing up your home-laboratory ware, for example, must be carefully rinsed away; otherwise the natural alkalinity of these substances would ruin the delicate test that determines whether soil is acid or alkaline.

You might imagine that a simple way to test the acidity or alkalinity of the earth from your garden would be to break a moist lump of it in two, press strips of blue and red litmus paper between the halves, and observe the final color of the test strips. This will not work, however, as litmus is not nearly sensitive enough for soil testing.

The "indicator" or testing material that will serve your purpose is a solution, in water, of a dye commonly spoken of as "brom thymol blue." If you like tongue-twisters, you can call it by its full chemical name, "dibromothymolsulphonphthalein." You can obtain the small quantity of the dye that you will need, in dry form, from any well-stocked dealer in chemicals or microscope supplies. Take a tenth of a gram of the test chemical and dissolve it in about 200 cubic centimeters (nearly a drinking glass full) of water, meanwhile heating the water gently—say, to sixty degrees centigrade (140 degrees Fahrenheit). Then dilute the solution with more water to a total volume of about 330 cubic centimeters. Tap water may

THIS SIMPLE TEST READILY REVEALS THE PRESENCE OF PHOSPHORUS



Place a half teaspoonful of the earth in a test tube and add a small amount of water

Now add one drop of "one-to-three" acetic acid (one part glacial to three parts water)

After shaking the contents of the test tube for half a minute filter into a beaker be used if necessary; to insure accuracy, however, it is always preferable to use distilled water in making up reagents, or test solutions.

Brom-thymol-blue solution responds to an alkali, even in small amounts, by turning blue. When the dye solution is made neutral—neither acid nor alkaline—it takes on a dark-green hue. In the presence of an acid, it turns yellow or orange, according to the degree of acidity.

For soil testing, the solution should be neutral or dark-green. Therefore, the yellow solution you obtain from the solid dye must be neutralized with clear, filtered limewater (calcium hydroxide solution). A few drops should be sufficient. Don't attempt to judge the color of the brom-thymol-blue solution by looking at a bottleful or beakerful; pour a sample of it into a test tube, and hold the tube between your eyes and the light. If you have added too much limewater, the liquid will be blue. A drop or so of extremely dilute acid (taken from a solution, say, of one drop of strong sulphuric acid in 300 cubic centimeters of water) may then be added to the entire batch of dye solution to bring back the correct color. If you use too much acid and the solution becomes yellow, add limewater again, and so on, until you finally obtain the dark-green color that you want.

Keep the test solution, if possible, in a bottle made of the kind of glass used in transparent oven ware. Ordinary glass is slightly alkaline and may turn it blue; however, its color may always be corrected immediately before use, as just described.

To test the soil in any garden or field with your solution, collect bits of earth here and there and mix them thoroughly to obtain a representative sample. Then place a pinch of the soil upon a glazed white porcelain plate, a bathroom tile, or an artist's slab. Add enough of the neutral test solution to the soil to make it watery. Also place a few drops of the solution elsewhere on the plate, for comparison and to make sure it has the proper dark-green color. After half a minute, carefully tilt the plate, allowing the liquid to drain from the soil and flow across it. If this solution is now yellow or orange, the soil is acid. If the drained liquid is blue, the soil is alkaline.

Gardening books will supply the rest of the information you need—the soil requirements of various plants. Azaleas, rhododendrons, mountain laurel, and broadleaf evergreens, for example, prefer an acid soil. If they are planted in a soil that is alkaline—say, one containing limestone, building plaster, or lime—they will surely die. The soil may be replaced with earth from the woods, or may be treated with applications of ammonium sulphate, aluminum sulphate, tannic acid, or flowers of sulphur, to put the plants in their proper environment.

Your brom-thymol-blue solution will also come in handy for testing the water of your outdoor lily pool and your indoor aquarium. This water should be faintly acid, if your fish

Put a piece of sheet or lump tin in a little of the filtrate and add test solution

If a blue color appears in the liquid, the soil contains the desirable phosphorus

To prove that soil readily absorbs potassium, let a solution of potassium chloride or potassium carbonate seep through soil in this apparatus. The liquid that comes out contains hardly any of the potassium

Traps for insects are made by spreading a poisonous mixture in jar lids and bottle caps

The dye solution used in testing soil for acidity or alkalinity should be made neutral by adding limewater or a weak acid solution, as needed, until it takes on the characteristic dark-green hue

TESTING THE SOIL FOR ACIDITY

Place a pinch of the soil on a bathroom tile and add enough of the test solution to make it watery. After half a minute, drain off the liquid and observe the telltale color are to thrive. To a ten-cubic-centimeter sample of pool or aquarium water, add half a cubic centimeter of the dark-green soil-testing solution. If the liquid turns blue, then it is alkaline, and the contents of the entire aquarium snould be acidified with a drop or two of very dilute muriatic or sulphuric acid. Repeat your test after you have done this. If the sample now turns yellow or orange, it is definitely acid—in fact, too much so. Aquarium water of the correct acidity should give an in-between, greenish-yellow color with your test solution. If the dark-green color of the reagent undergoes no change whatever, the water is neutral; it will support fish life, but not as well as water that is very slightly acid.

'e solution used for testing the acidity of your soil also will tell you whether water in your indoor aquarium is acid or alkaline. It should be faintly acid

Phosphorus contributes to the fertility of soil, in the form of phosphates of calcium, magnesium, and iron. You can test earth from your garden for the presence of phosphorus with an easily prepared reagent. Dissolve about two and a half grams of ammonium molybdate crystals in twenty-five cubic centimeters (about seven teaspoonfuls) of distilled water using heat to hasten solution. Filter the resulting liquid, if it is turbid. Then pour it into twenty-five cubic centimeters of pure, strong nitric acid. Finally add fifty cubic centimeters more of distilled water. Keep the solution in a glass-stoppered bottle.

TO TEST soil for phosphorus, place about a half teaspoonful of the earth in a test tube and add water to make a total volume of about thirteen cubic centimeters. Now add one drop of "one-to-three" acetic acid (one part of strong or "glacial" acetic acid to three parts of water). Shake the contents of the test tube for half a minute, and filter. To one cubic centimeter of the filtrate, or liquid that passes through the filter, add a piece of clean sheet or lump tin (not "tin" foil from a candy bar, which is actually aluminum) and five cubic centimeters of your ammonium molybdate test solution. If a blue color appears—a reaction requiring about half a minute—then the soil contains the needed element phosphorus. The depth of the shade of blue indicates the amount of phosphorus present.

Plants require nitrogen, too, and get it from nitrate compounds in the soil. You can make a nitrate test solution by dissolving three one-hundredths of a gram of an organic chemical known as diphenylamine in twenty-five cubic centimeters of strong, chemically pure sulphuric acid. Keep this strongly corrosive liquid in a glass-stoppered bottle. If its color changes in time to blue, brown, or pink, it is worthless for your purpose and a new batch must be made up.

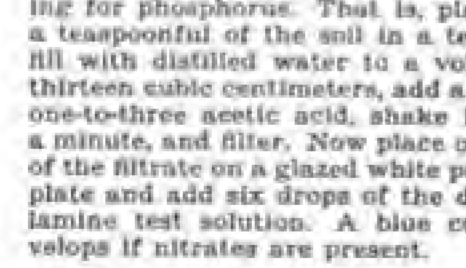
To test soil for nitrates, follow the same preliminary procedure as in testing for phosphorus. That is, place half a teaspoonful of the soil in a test tube, fill with distilled water to a volume of thirteen cubic centimeters, add a drop of one-to-three acetic acid, shake for half a minute, and filter. Now place one drop of the filtrate on a glazed white porcelain plate and add six drops of the diphenylamine test solution. A blue color develops if nitrates are present.

POTASSIUM, or "potash," in various forms of chemical combination, also serves as a valuable plant food in the soil. Solutions containing potassium give a yellow precipitate when treated with a reagent known as sodium cobaltinitrite. To prepare this, mix two cubic centimeters of a ten-percent solution of sodium nitrite (not nitrate), five or six drops of a dilute (say, ten-percent) solution of cobalt nitrate, and one cubic centimeter of strong (glacial) acetic acid.

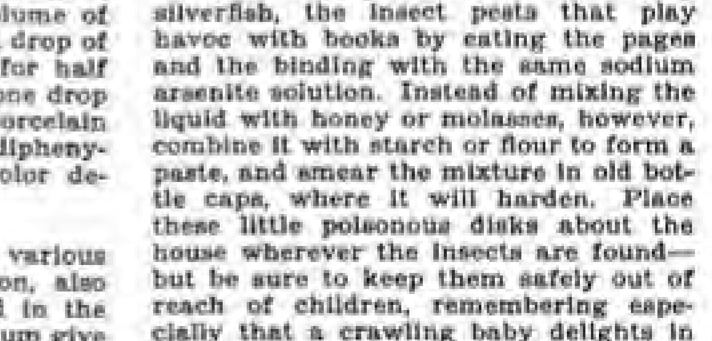
With this reagent, you can show that a fertilizer rich in potassium, such as potassium chloride or potassium carbonate, can be applied to the soil with the assurance that little of the compound will be carried away by drainage or excessive rainfall. Dissolve about a gram of either of these potassium chemicals in a liter (roughly a quart) of water, and let the solution seep through ordinary garden soil in a vertical glass tube of about one-inch diameter. The liquid may be admitted a little at a time through a "choked-stem funnel," made by plugging an ordinary glass funnel with a short strip of rubber tubing and using a pointed glass rod as a stopper. The bottom of the one-inch tube contains a wad of absorbent cotton that holds in the soil and allows the solution to filter through. Test the liquid that has passed through the soil with your sodium cobaltinitrite reagent. You will observe little or no yellow precipitate, while the original solution gives a conspicuous amount, showing that the soil effectively absorbs the potassium.

ANTS can be a nuisance both in the garden and in the home. You can make a good ant trap by first dissolving about three quarters of an ounce of ordinary washing soda, and then about an ounce of arsenious oxide (called also white arsenic), in a quart of water. This makes a solution of sodium arsenite. Since it is poisonous, do not use any household utensil in making it up, but employ a tin can that can be thrown away afterward. Mix one fluid ounce of your solution with about a pint of honey or molasses, to serve as bait for the ants. Pour the mixture over pieces of wrapping tissue, or excelsior, resting in old preserve-jar lids, and place the traps about the garden and the house.

Incidentally, you can readily destroy silverfish, the insect pests that play havoc with books by eating the pages and the binding with the same sodium arsenite solution. Instead of mixing the liquid with honey or molasses, however, combine it with starch or flour to form a paste, and smear the mixture in old bottle caps, where it will harden. Place these little poisonous disks about the house wherever the insects are found—but be sure to keep them safely out of reach of children, remembering especially that a crawling baby delights in putting every conceivable object in its mouth. The poisonous ant traps, of course, should be hidden or safeguarded.



Fractions of a gram of a chemical can be measured by dividing a larger, spread-out amount

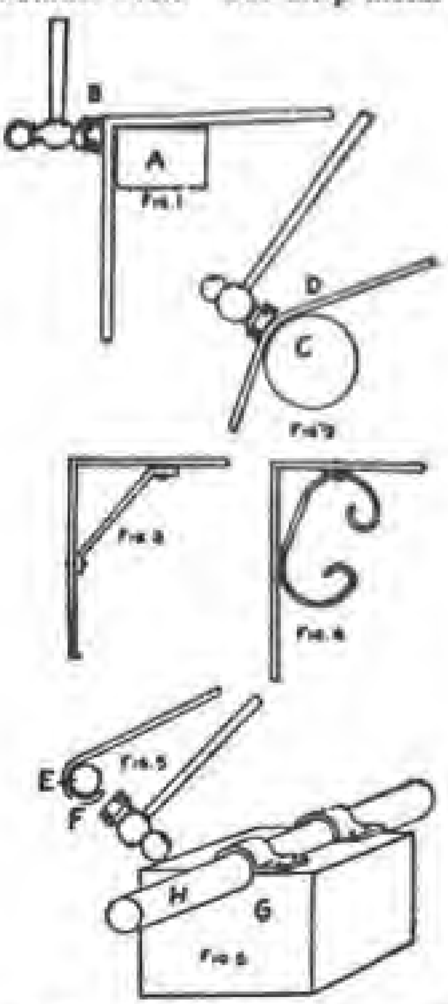


Easy Designs in Ornamental Iron Work

From Popluar Mechanix 1913

Many an industrious lad has made money manufacturing the common forms of wood brackets, shelves, boxes, stands, etc., but the day of the scroll saw and the cigar-box wood bracket and picture frame has given way to the more advanced and more profitable work of metal construction. Metal brackets, stands for lamps, gates, parts of artistic fences for gardens, supporting arms for signs, etc., are among the articles of modern times that come under the head of things possible to construct of iron in the back room or attic shop. The accompanying sketches present some of the articles possible to manufacture.

First, it is essential that a light room be available, or a portion of the cellar where there is light, or a workshop may be built in the yard. Buy a moderate sized anvil, a vise and a few other tools, including bell hammer, and this is all required for cold bending. If you go into a forge for hot bending, other devices will be needed. Figure 1 shows how to make the square bend, getting the shoulder even. The strip metal is



secured at the hardware store or the iron works. Often the strips can be secured at low cost from junk dealers. Metal strips about ½ in. wide and ⅛

THE REAL ENERGY CRISIS

by Kurt Saxon

A while back, President Carter admitted to the nation that by 1985 the world will be using more fuel than it produces. This was a promise of doom for the majority of the Earth's population, but few understood it as such.

Consider: Unrenewable fuels maintain world civilization. The world's standard of living has been dropping steadily for years due to the increasing scarcity and consequent higher costs of fossil fuels. The cheap and easy to get fuel has all been gotten, except for various limited government and privately owned reserves.

Now drillers go deeper for oil. They go to undeveloped areas for it. They drill under the oceans for it.

Coal companies must dig deeper for coal. They must move more earth to get it even if it is close to the surface. Stripped land over coal beds must be replaced at high costs.

Oil and coal must be transported greater distances, adding to its cost.

All this is pricing many home owners out of the fuel market. Prices for manufactured goods go up constantly as a result of higher energy costs.

So as bad as things are, they will get worse. Carter implies that by 1985 the home owner will have gone as far as he can go. At that time he will be one of the priorities dropped in favor of industry. This also applies to gasoline for privately owned vehicles.

So in 1985, when more energy is being used than is produced, the private individual won't be able to buy petroleum products at all and the coal for homes will cost at least three times as much as it does now.

So by Carter's figures, your world ends in 1985. Of course, he's only a politician and isn't expected to know anything for sure. His understanding of the problem comes mainly from other politicians, wishful-thinking Liberal trash, for the most part, who don't dare tell it like it is.

They collect the statistics and set the deadline for real trouble always an election or two in the future. The present figure of 1985, eight years in the future, is childishly optimistic in light of the worldwide climate changes. Another super cold winter will knock off a projected year due to more emergency fuel use. Then the turning point year will be 1984. If the following winter causes still another fuel drain, the projection will then be 1983, and so on.

And don't forget the drouth. Going deeper or farther afield for water takes enormous supplies of energy.

No politician can accept the death of his constituency any more than your average flea could comprehend the death of his dog. The worse things get, the more a politician will implement purely political solutions. This involves transferring responsibility from one agency which can't handle a problem to another agency which can't handle it.

Thus, everyone looks busy and the public is pacified for a little while longer. Then the optimists start beating the tired old drum about shale oil, offshore oil, Alaskan oil, more effective use of coal, solar power, wind power, etc. By 1985, they imply, new sources of energy will replace what is running out now.

In the case of shale oil they estimate 600 billion barrels. But companies that have investigated the costs of wringing it from the rock are bailing out. A plant capable of producing 100,000 barrels of oil a day would cost $1.5 billion and could not sell the oil for less than $18 a barrel. Arab oil costs $12 a barrel. You can be sure that by the time Arab oil goes to $18 a barrel, shale oil will cost even more.

These figures don't take into account the fact that the shale oil deposits are in an arid region. It takes massive amounts of fresh water to process shale oil operations. The area has barely enough for agriculture and public use. Forget shale oil.

If you want a laugh, or a good cry, consider offshore oil. Leaks and blowouts from offshore rigs are an ecological nightmare. Blowouts have happened before and still, a professional crew can put a blowout preventer on in. thick are preferable. The letter A indicates a square section of iron, though an anvil would do, or the base of a section of railroad iron. The bend is worked on the corner as at B, cold. If a rounded bend is desired, the same process is applied on the circular piece of iron or the horn of an anvil. This is shown in Fig. 2, at C. This piece of iron can be purchased at any junk store, where various pieces are always strewn about. A piece about 20 in. long and 4 in. in diameter is about the right size. The bend in the metal begins at D and is made according to the requirements. Occasionally where sharp bends or abrupt corners are needed, the metal is heated previous to bending.

Although the worker may produce various forms of strip-metal work, the bracket is, as a rule, the most profitable to handle. The plain bracket is shown in Fig. 3, and is made by bending the strip at the proper angle on form A, after which the brace is adjusted by means of rivets. A rivet hole boring tool will be needed. A small metal turning or drilling lathe can be purchased for a few dollars and operated by hand for the boring, or a common hand drill can be used. Sometimes the bracket is improved in design by adding a few curves to the end pieces of the brace, making the effect as shown in Fig. 4. After these brackets are made they are coated with asphaltum or Japan; or the brackets may be painted or stained any desired shade.

In some of the work required, it is necessary to shape a complete loop or circle at the end of the piece. This may be wrought out as in Fig. 5. The use of a bar of iron or steel is as shown. The bar is usually about 2 in. in diameter and several feet in length, so that it will rest firmly on a base of wood or stone. Then the bending is effected as at F, about the bar E, by repeated blows with the hammer. After a little practice, it is possible to describe almost any kind of a circle with the tools. The bar can be bought at an iron dealers for about 40 cents. From the junk pile of junk shop one may get a like bar for a few cents.

A convenient form for shaping strip-metal into pieces required for brackets, fences, gates, arches, and general trimmings is illustrated at Fig. 6. First there ought to be a base block, G, of hard wood, say about 2 ft. square. With a round point or gouging chisel work out the groove to the size of the bar, forming a seat, by sinking the bar, H, one-half its depth into the wood as shown. In order to retain the bar securely in position in the groove, there should be two caps fitted over it and

upside down, as happened in the North Sea. That caused 8.23 million gallons of oil and mud to spew out in eight days, creating a 4200 square mile oil slick. First reports indicate little ecological damage. But all that oily mud settling on the spawning beds may just ruin hundreds of square miles of fishing grounds.

Phillips Petroleum lost $120 million on that blowout. That will be passed on to you.

Ecologists are against atomic energy because of the risks. The risks in offshore drilling are far greater.

Alaskan oil was touted as the big oil crisis bailout. Now it is acknowledged to be only a temporary stopgap, if that.

Greater use of coal is seen by many as a way to relieve the fuel crisis. Coal is not the answer. It is becoming harder to get all the time, which makes it increasingly more expensive. Companies using it will have to install scrubbers to remove most of the sulphur and other pollutants, adding more charges to everyone's bill.

Most average people with some foresight resign themselves to the eventual use of coal over oil. They say coal was used before oil and will take over after oil is no longer available.

This sounds fine except that coal is a major pollutant. It was replaced by petroleum largely for this reason. In 1870 the sulfuric acid given off by burning even high quality coal having the least sulphur content was eating away the buildings in New York City. (See editorial, page 46).

In 1870, New York City had a population of 942,292. Today, New York City's population is about ten times that.

Even with scrubbers, coal burned for about ten million New Yorkers would kill them all. White House Energy Advisor, James Schlesinger now says that New York City and Los Angeles won't have to burn coal. This would have to apply to just any city with smog problems.

If your city has a smog problem, you should realize that even scrubbed coal would intensify the problem to the critical level. So since city dwellers, largely unemployed, can't maintain the rising utility costs, the cities will die.

If coal were used nationwide in quantities Carter envisions, coal pollution would be catastrophic. In 1870 our population was only 38,558,371 and coal pollution was a serious problem. There are about 200 million more people in the U.S. today.

Concerning solar and wind energy, read my editorial on page 36.

Over the weekend, the TV carried a story of clam bed pollution off Long Island in New York. Health officials had extended the off-limits zone for clamming another 300 yards out.

This was due to the sewage New Yorkers allow to run off into the Atlantic. Clam pirates were violating the area and taking potentially contaminated clams to sell to their fellow New Yorkers. Aside from the pirates, most clammers were either digging clams further out or going out of business.

Logic would suggest that the sewage should be kept out of the ocean, both for the safety of swimmers and to insure the purity of the food taken from offshore waters.

New York has a smog problem and a sewage pollution problem. By diverting the sewage into methane generators, one problem would be solved and another eased. The methane from the sewage would go for cleaner power and the ocean food would be made safe.

Friends or Allies: Choice for Survival

By Kurt Saxon

In the 1950s, several thousand people had nuclear fallout shelters built, usually in their back yards. At first they met only ridicule by those neighbors who considered themselves above such hysteria.

In time, however, it occurred to those neighbors that something had changed in their relationship with the shelter builders. Often, those who had set-screwed to the wooden base. These caps may be found in junk dealers' heaps, having been cast off from 2-in. shaft boxes. Or if caps are not available, the caps can be constructed from sheet metal by bending to the form of the bar, allowing side portions or lips for boring, so that the caps can be set-screwed to the wood. Thus we get a tool which can be used on the bench for the purpose of effecting series of bends in strips of metal.

Since the introduction of the laws requiring that signs of certain size and projection be removed from public thoroughfares in cities, there has been quite a call for short sign brackets, so termed, of the order exhibited in Fig. 7. These sign-supporting brackets do not extend more than 3 ft. out from the building. A boy can take orders for these signs in almost any city or large town with a little canvassing. The sign supporting bracket shown is merely a suggestion. Other designs may be wrought out in endless variety. A hook or eye is needed to sustain the ring in the sign.

The young man who undertakes to construct any sort of bracket, supports, frames or the like, will find that he will get many orders for lamp-supporting contrivances, such as shown at Fig. 8. It is hardly necessary to go into details

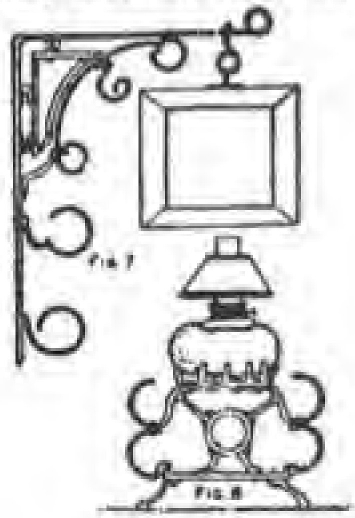


Fig. 7

Fig. 8

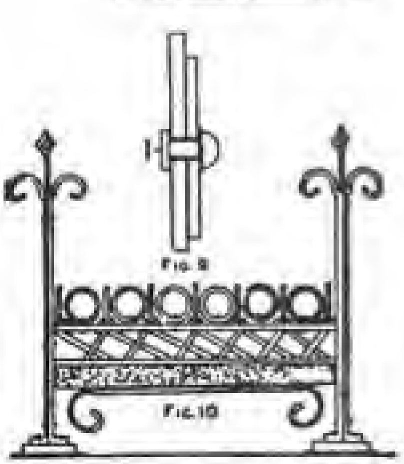


Fig. 9

Fig. 10

for making these stands, as every part is bent as described in connection with the bending forms, and the portions are simply riveted at the different junc-

been friends for years came to despise each other.

It usually started like this: Sam would say to Paul, the shelter builder, "Paul, I don't believe there's going to be a war. But if it happens, I'll know where to come."

Paul would say, "But, Sam, it's not a matter of belief. If it happens it'll happen and if it doesn't happen, it won't. Neither of us believes our homes will burn down some night. But we both have fire insurance. So my shelter is simply my nuclear war insurance.

"What if you had fire insurance and I didn't? If my house burned down, without insurance, I could never rebuild. Would you allow me to move my family in with you on a permanent basis?"

Sam might say, "But that's a poor analogy. I'd be glad to put you up for a few weeks and even help you to rebuild."

"But," Paul would reply, "We both make about the same wages. What if I bought a boat instead of fire insurance, thinking, "What the hell, I'd rather play with a boat than sit around home worrying about an unlikely fire. Besides, good old Sam will bail us out. He's our ace in the hole.

"Would you want to be our ace in the hole if we left our welfare up to you while we ran around in a damn boat while you sat home worrying about a fire?"

"Harping on the boat again," says Sam. "I said you could use it."

"Forget the boat," says Paul. "The point is, that you considered the boat more important than nuclear war insurance. You have all kinds of insurance but you don't seem to know what insurance is. It's not negotiable. You have hospital insurance and I don't and I get sick; tough on me. You buy fire insurance and I don't and my house burns down; your insurance company wouldn't rebuild my house.

"Like your life insurance, my shelter is nuclear war insurance which covers only my family. If you want that kind of insurance, buy it. Don't expect to use mine."

By now, Sam is seeing that friendship has its limits and he resents it. "Okay," he says, "Just suppose your war should break out. So I haven't prepared. But we've been friends for years and I never put you off when you needed help. And you've always been on hand to help us. But now, when it's a matter of life and death, our friendship isn't worth a bo-diddly? Is that what you're telling me?"

"It's not a matter of friendship," says Paul. "My shelter was built for my family of five. It's for two weeks; maybe four if we absolutely had to stay longer. You crowd your family of five in there and we'd all be dead in a week."

"Maybe so," says Sam, "but the point is, you would just keep us out, knowing we would all be sprawled around the door, dead as mackerals. (He breaks into sobs.) And my littlest, Jenny, she's only five, you know. Before I'd let you close her out, I'd come with a gun."

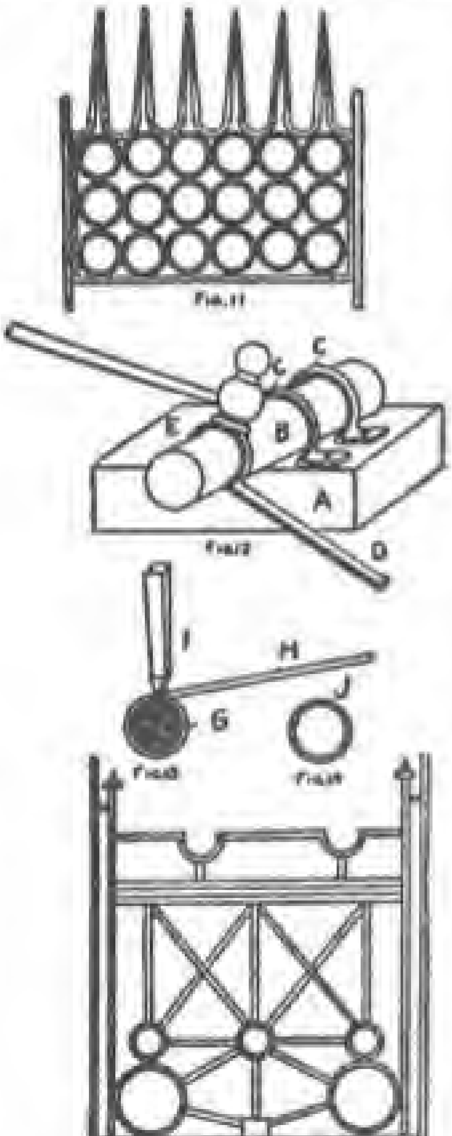
Such arguments would go on to the point where the neighbors were no longer friends. I never heard of a case where, rather than break up as friends, the other neighbor built a shelter.

Telling the improvident their time is running out seldom motivates them to prepare. The improvident are the improvident. That's their nature. They know their basic helplessness, but will seldom admit it. They are more likely to react with hostility to survival advice than to begin their own preparations.

The difference between one who prepares and one who doesn't is more important than a difference of opinion. If you prepare to survive, you deserve to survive. Those who can, but won't prepare, don't deserve to survive and the species would be better off without them. If you have the kind of intellect that's geared to survival, it may be a matter of genetics. Your neighbor may lack these survival genes. Therefore, becoming his means of survival could not only doom both of your families to death, but if you should make it, you would have enabled a non-survival type to further pollute the gene pool. That's a no-no, although you might take in one of his brighter children if you really have enough room. If you are really in a position to save someone, you tures. Both iron and copper rivets are used as at I, in Fig. 9, a cross sectional view.

The best way is to bore straight through both pieces and insert the rivet. In some cases the rivet is headed up in the bore and again washers are used and the heading effected on the washer. Copper rivets are soft and easily handled, but are costly as compared with iron rivets.

Good prices are obtained for the guards for open fireplaces made in many varieties in these days. The return of the open fireplace in modern houses has created a demand for these guards and in Fig. 10 we show a design for one of them. The posts are made



sufficiently stiff by uniting two sides with rivets. The ends at top are looped as shown, while the ends or butts at the base are opened out to make the feet. Rings are shaped on forms and are then riveted to the base cross-piece as illustrated. Crosses are made to describe to central design and the plan is worked out quite readily with the different shapes.

The making of metal fire grate fronts has proven to be a very interesting and profitable occupation for boys in recent

ought to be selective. But don't be too callous. Without basic human compassion, you might not be worthy to survive, yourself. Aside from making you seem callous towards others, your preparations puts you out of the Good-time-Charley field and you are seen as a part of the establishment. You are then no longer a buddy, but someone to use when things get rough. It's hard to explain but it's sort of like when you go into business for yourself; your wage-earning friends tend to drop away. You have a kind of security they can't aspire to. So they either drop away as friends or become actually hostile.

So you see, friendship ends when you establish a permanancy and security your friends can't aspire to. Maybe they don't care to put out the extra effort or money. Maybe they're just lazy or stupid. It doesn't matter why they drop away. Just recognize the fact that Survivalists are likely to see their friends drift away.

So don't expect to impress a friend with your preparations. It's far better to get him sold on the idea of making his own preparations.

It's very likely you can't get your friend to exert himself to make any survival preparations. Serious preparation would upset his whole lifestyle.

Most neighbors would rather rationalize away the danger than do something about it. Say you bought a house on an earthquake fault. So a guy comes and tells you you'd better move or get shook to pieces.

So there you are, with everything you have threatened with destruction. A Survivalist would move, taking his losses in money, energy and time.

But the average person would rationalize away the danger and never bring up the subject again. If he was smarter than average he would try to unload the property on some sucker, of course, never mentioning the fault.

So if you broach the subject of survival to a friend and he gives you the horse-laugh, just think of him as one who knows his house is built on an earthquake fault. He'll give you nothing but rationalizations as to why nothing will happen. Best just to ease away from him and tell him nothing further of your plans.

Since survival is the most important subject today, and only a few recognize it, you can't waste time with friends who have little potential as allies. The time is coming closer when if a neighbor isn't an ally, he's highly likely to become an enemy.

Only those who are working on their own survival programs are fit to associate with at this point. I'm not suggesting you snub your friends or give up on non-survivors altogether. This would be rude and stupid. Besides, an intelligent friend might finally come around to your way of thinking as things get worse.

So just be businesslike when talking survival. It's very serious, so the drinking buddy would be more likely to be offended than interested.

In survival programs, an ally is worth any number of friends. In the coming months, you will learn to sort out your allies, who are aware of the coming crash, from your friends, who think you're a nut if you worry about anything but where your next baseball ticket is coming from.

As you come in contact with more Survivalists, you will be bored with your old buddies, anyway. And they will be bored with you, too. So don't feel panicky at the thought of your old cronies drinking without you.

Of course, your first choice of allies should be among your friends, especially neighbors. If you and your neighbor both had a roomy, livable shelter, you could link them up with a tunnel.

Such a setup would enable you to share the burden of buying supplies. Tools, books and the various items of hardware could be shared, rather than having to buy two complete sets for two families.

Linked shelters would also permit visiting for moral support and economy. They would also be handy to resist assault. If one's shelter were under assault by the mob, the other could go through the tunnel and help fight them off. When the mob finally gave up and went off to die of radiation sickness, life in the shelters could become downright social.

In this way you can see how a neighbor who is an ally can be of great times. Not long ago it was sufficient for the ingenious youth to turn out juvenile windmills, toy houses and various little knickknacks for amusement. The modern lad wants more than this. He desires to turn some of his product into cash. Therefore we present some of the patterns of fire grates which boys have made and can make again from scrap iron, with few tools and devices, and find a ready market for the same as soon as they are made. Figure 11 is a sketch of a form of fire grate bar or front that is constructed with a series of circles of strip metal. The best way is to go to the hardware store or iron dealer's and buy a quantity of ¼-in., ½-in., and ¾-in. iron, about ⅛ to $\frac{3}{16}$-in. thick. In fact $\frac{1}{16}$-in. metal would do in many cases where the parts are worked out small in size. The ⅛-in. metal is very strong. Then after getting the supply of strip metal in stock, procure the usual type of metal worker's hammer, a cheap anvil, a 9-lb. vise, a cold chisel, a file or two, and a round piece of shaft iron, about 3 in. diameter and 2 to 3 ft. long. This piece of iron is represented at B, Fig. 12.

The iron is held in position by means of the straps of metal C, C, which are bent over the shaft tightly and grip the board base with set or lag screws as shown. The wooden base should be about 2 in. thick and large enough to make a good support for the iron shaft. The process of bending the rings in this way is as shown. The piece of strip iron is grasped at D. Then with the hammer the iron is gradually worked cold about the mandrel as at E until the perfect form is acquired. After the form is finished, the strip at the terminus of the ring is cut off. In order to get a steady base the wooden part may be bolted to a bench. In Fig. 13 is shown the method of clipping off the completed ring. The cold chisel is held upright, and by delivering several blows with the hammer upon the same, the point is caused to chip through the metal and release the ring. The shaft or mandrel is marked G. The cold chisel is indicated at I and the position where the hand grasps the strip is at H. The final operation in shaping the ring is by driving the protruding cut, lip down, to the common level of the opposite point, thus giving us the finished ring with the lips closed on the mandrel as at J, Fig. 14. These rings can be turned out in this way very speedily. The next operation involves the process of uniting the rings in the plan to shape the design. The design work is often worked out ahead and followed. Some become so proficient that they can develop a design as they proceed.

benefit. But a neighbor who depends on you to save his bacon is not only not an ally but he could become your worst enemy.

One way to help a neighbor to become an ally is to introduce him to other Survivalists. Then he will feel that you're letting him in on something. Also, if you have three or four guys in your home talking survival, your neighbor will feel he's the isolated minority in his stand that this is the best of all possible worlds.

Even if your area is an unlikely target for a nuclear bomb and underground shelters are not in your plans, the ally principle is still very important. You just can't waste time with a friend who is of no use in your survival plans.

An ally can be a person you don't even like, socially. But if your ally shares your enthusiasm for survival, he will be far more useful to you than a friend who agrees with you on everything but survival.

PARANOID, FROM PAGE 556

A guy hiding his survival preparations might as well forget it. His neighbors are more important to his chances than any survival gear. The neighbors I'm talking about are working people who are acquaintances and potential friends. I'm not suggesting one share his plans with welfare bums, winos, dopers and general trash. No, I'm talking about decent people who simply don't share our views at this time. These people will come around to our way of thinking in time.

The Survivalist's early preparations will give him status in his neighborhood as things get worse. The neighbors will listen to him in the near future if he will only give them the chance to agree with him now. But if he automatically writes them off as hostile and potential looters, that's exactly what they'll be when things get really bad.

I think some of you get survival preparations confused with having a fallout shelter. If you had a shelter and your neighbors didn't, you would be severely mobbed in the event of a nuclear war. Your neighbor's lives would depend on getting in. But an extra supply of food, weapons and trade goods in your home would not give rise to panic. There would be nothing immediate about it.

There won't be a government message saying that everyone with a stock of survival goods will live and those without will die, period. There won't be a stampede to your place. Before things get bad enough for your neighbors to loot you, they will still have time to imitate you, although not as cheaply or with your wide selection.

But let's say you're a real Secret Squirrel and have made your home a storehouse of arms, food, etc. No one knows and finally the system collapses and your neighborhood goes through the turmoil you might expect.

Now your neighbors, who you've considered enemies, have managed to fight off some bands of looters and are setting up neighborhood defense and help organizations. Instead of being among the leadership, you are simply one who shares what they have because they think you are in need.

You're in real trouble because if your neighbors find out you've been holding out and taking help from them, they'll shoot you. If you don't take their help, they'll find out why and shoot you for holding out.

Your only real chance now is to give your neighbors the benefit of the doubt or move to an isolated farm. In any event, the more allies you have, the better your chances. But if all you see now are enemies, that's all you'll see when you need friends the most.

Survival Shelters and the Dependent Aged

By Kurt Saxon

"Dear Mr. Saxon:

"I really enjoyed Vol. 2, No. 6 (Pages 235-250) of THE SURVIVOR. Especially the article "Survival of the Fittest," by Tom Murphy, and "The Survival Shelter," by yourself. However, at the end of your shelter article you wrote something that is very disturbing to me, regarding older people.

"You state, 'Steel yourself to keeping her out. Better to reject anyone whose life in nearly over.' Later you mention the elderly, unbelievably to me, along

Figure 11 is a design of grate front used for various purposes in connection with grate fires. The series of rings are united by a rivet between each at the joining point. With thin metal the holes can be punched with an iron punch and hammer on an anvil where there is a hole to receive the point of the punch after the punch penetrates the metal. For the heavier forms of metal a drill is necessary. A metal drill and brace can be purchased very cheaply for this work. After drilling the holes, the parts are erected and the rivets inserted and headed up as each addition is made. Thus the series of rings are united and then the side pieces are similarly riveted. The points at the top are then worked out and joined on. These points are filed down to the necessary taper after the union is effected. The finishing work involves smoothing rough places with a file and painting. Asphaltum makes a good black finish. Some of the best designs of grates are bronzed. Some are silvered. The different designs are finished as desired by customers.

Figure 15 is another design of grate in which the process of shaping the rings is like that in the first design. There are some half circles in this pattern and these are framed by shaping

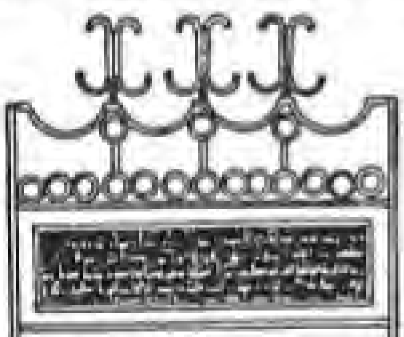


Fig. 16

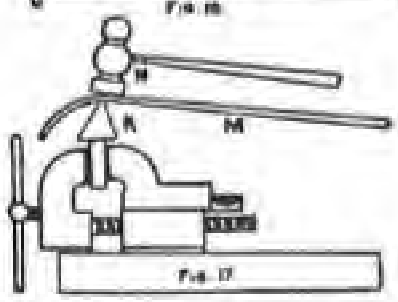


Fig. 17

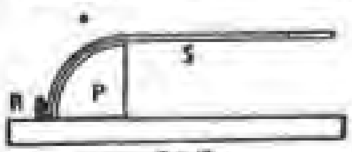


Fig. 18

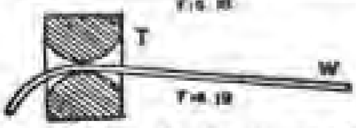
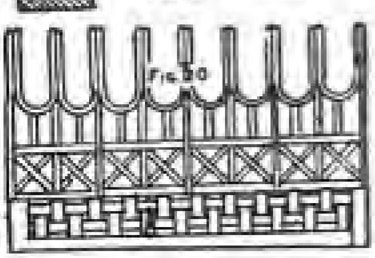


Fig. 19



with the retarded, criminals and perverts, as 'unfortunate and helpless.'

"**Mr. Saxon**, I could hardly believe what I was reading. I had to check again who it was that wrote the article. I was disappointed to see that you did. Is this all you think of older people? Let me speak in their defense.

"**First of all**, who can consider anyone over 70 years old as anything but a Survivor? What about all the priceless knowledge they have accumulated? These old folks lived the very life that we Survivors will face some day. Who better to have in a shelter with you? Did you ever meet an older person who didn't know about animals and gardening? I never have. Old folks need very little sleep and very little food. If not senile, most of them are walking encyclopedias and history books.

"**In short**, they have been where we are going. How can you suggest that we turn such valuable resource away from our shelters? I would sooner have an old man or woman with me than nearly any useless young punk or bitch.

"**To think** that you, of all people, would classify old folks as parasites really makes me think twice about where your head is at.

"Well, you've done so well otherwise that I will allow you this one mistake, drastic as it is. Please think about it, Mr. Saxon.

Sincerely,
Ron B.
Calif.

The above letter is typical of many idealistic Survivalists. Without love and compassion for others, society would be a worse jungle than it is. However, I think a lot of my readers may just doom their own hopes of survival by including in their programs those who could not survive without our modern technology, anyway.

A person of seventy who is hale and hearty, has his wits about him and is making his own survival plans, may have a better chance than most younger Survivalists. Such a one would be more likely to keep me out of his shelter than the other way around. I'm not worried about the self-reliant elders, who make up a big proportion of my readership.

The type of elders I suggest excluding are those who have given life their best shot years ago. They are retired, feeble and given to dozing when not watching soap operas.

Increasingly, we read of elders stealing food from stores. Never on a police blotter before, but now they are brought in for petty theft. Others scrounge for food in garbage cans. These are the improvident. Their whole working lives were spent earning wages from others. They were never self-reliant in the first place. They end their days in miserable little rooms, rest homes or in a corner of their often grudging children's homes. All such elders are too dependent on a given system to survive without it.

Being old is nothing to be ashamed of but the sanctity of age for its own sake is a myth.

The Granddad image I've tried to project through so much of my writing has nothing to do with old people. "Granddad" was a young person, 20-40, living in the nineteenth or early twentieth century. The most important quality he possessed was self-reliance. Self-reliance has always been the individual's best guarantee of survival.

In those days there were no supermarkets and people did have to know how to do a lot for themselves. Only the affluent paid others to do services around the home. The average person had to do for himself or do without. Today, the average person will call in a $15.00 an hour plumber to put a washer in the sink faucet.

As goods and services became more available and cheaper, more people became less self-reliant as a matter of course. This is normal. A woman who would scrub floors on her hands and knees with all the labor savers on the market would be stupid. A man who learned a dozen household skills just to save money would be just as stupid. (For other than a faucet washer, I call a plumber).

In the last century, survival skills were not simply a person's trade, but consisted of home maintenance, food processing and such. Later, a man the same about the mandrel with the hammer. In order to get the shoulders close and the circle complete it is necessary to heat the metal. A coke fire can be made in a hole in the ground. Then procure a tin blowpipe and blow the flame against the metal at the point to be bent. This metal will become red hot very soon, and can be bent readily against the anvil and the circular form. Let the metal cool off on the ground after heating. Fig. 16 is another design which can be wrought out. The middle adjustment is wire screen work which may be bought at a hardware store and set into the position shown. Fig. 17 shows a chipping off device useful in connection with this work. Metal chippers can be bought at any tool store. The chipper is placed in the jaws of the vise as at K, and secured there. The strip of metal in process of cutting is marked M. The hammer head is caused to strike the metal just over the cutting edge of the chipper. The quick, hard blow causes the cutting edge to penetrate far enough to sever the piece. Bending cold with a wooden form is done as in Fig. 18. The wooden form is marked P and is about 8 in. wide and 7 in. high, forming a one-sided oval shape. There is a pin R set into the base board of the oval form and the strip of metal for bending is grasped at S and the other end is inserted back of the pin R. By applying pressure, the strip of metal is bent to the form.

Figure 19 shows the hour-glass wood bending form, made by selecting a piece of hard wood block, about 6 in. square and boring through with an inch bit. Then the hole is shaped hour-glass like. The view is a sectional one. The block is placed in a vise and the strip for bending is inserted as at T.

The strip of metal is grasped at W and can be bent to various forms by exerting pressure. Fig. 20 is another type of fireplace front, constructed by uniting the shaped metal pieces. In fact an almost endless variety of designs can be wrought out after the start is once made. A good way to figure the price on the grate is to add up the costs of the parts and charge about 12 cents per hour for the work.

PLANING ARROW STICKS

From Popular Mech. 1919

While making some bows one day I discovered I had no suitable dowel sticks for the arrows, so I started to make them out of ¼-in. square stock. I found it rather difficult to plane these pieces until I hit upon the scheme

could be free of most of this drudgery at little cost. When people no longer needed most survival skills, later generations never learned them in the first place.

So what's all this about an older person being a goldmine of information? Take a 70 year-old person; born in 1907. By the age of 20; starting a family; well into a trade. Year, 1927.

By that time, the only survival skills the average American knew was the job that gave him his living. This was especially true in the towns and cities.

Women in the cities of 1927 were little more able to cope with gut-level survival situations than are women today. They didn't raise livestock, make butter, soap, etc., and they bought most of their clothes and just about everything they needed. Farm women bought every labor saver they could afford from their Montgomery-Wards or Sears catalogues.

So the person who is 70 years-old today is hardly likely to be an encyclopedia of 19th century crafts. There are far more young people of today learning such skills than there are elders with any useful memories of such skills.

An old person is just someone like you or me who has lived a lot of years. If you stop learning after you establish a trade, you'll be no smarter at 70 than you are now.

At 45 I know many old people. I lived with old people during my college period when I lived at the Wino Arms in Long Beach, Calif. There were a lot of retired old fellows there, just waiting to die.

One was Cap, an ex-skipper with a memory which kept me amazed. He could remember every word that passed between him and a ruined woman he took up with on the old Bowery. He could detail the complete action of a brawl that happened in a Singapore dive in ought-seven.

But when I tried to pin him down to any relevent thing about the old days, I'd draw a blank. All he and the others could recall was personal trivia, having no practical or historical value. Later, when I got into this field and quizzed many elders about common old skills I lucked out completely. They all remembered people who knew such things, and some even remembered having done such things themselves. But when it came to detailing the process or updating it for today's use; forget it. They had no need to retain such knowledge, don't you see? So over the years they forgot critical steps in the processes they had had some knowledge of, the same as you or I would.

So put the matter of the old person in the shelter in its proper perspective. If you consider saving an elder under any survival circumstances, don't do it because you will need that person. With rare exceptions, you won't. If you save an elder it will be because you love that person.

Now that we've established (as far as I'm concerned) that saving an elder is most likely an act of sheer altruism, let's see what this would involve.

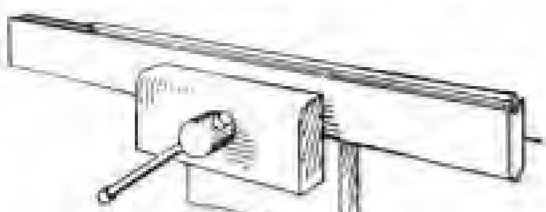
First of all, an elder is set in his ways and faced with the idea of going underground and then coming up to total chaos, he'd probably rather take all his prescription medicines at once and finish himself off.

Let's say, however, that he means to ride it out. (And when I say "he" I mean Granny, too). So the elder goes down into the shelter, finds it uncomfortable and boring and simply dies. It's as simple as that. When you are all battened down and the elder dies, as you must realize is almost a certainty, what would you do with the body?

Actually, the saving of persons whose further enjoyment of life would be cut off by such hardship would be cruel. Better to put a little something in the tea. Besides, if there is really room enough in your shelter for a person of little or no value to your survival programs, common sense dictates that that person should be a neighbor's child. At least a child has potential.

The question of whom to save in such a circumstance is largely academic. Who knows what horrible decisions an individual will have to make at the last moment?

There is a book that is out of print but which you might find in your library. It is "Flight in the Winter," by Jurgen Thorwald. This deals with Germany during the invasion by Russians at the end of WWII.



Planing the Corners from Square Stock by Placing Them in the Groove of a Flooring Board

shown in the sketch. I procured a piece of ordinary tongue-and-groove flooring and clamped it in the bench vise, then drove a nail in the groove to act as a stop, and in no time I had the sticks planed into arrows.

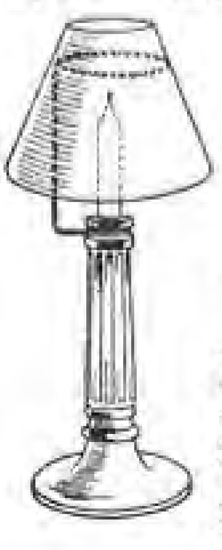
How to Bake a Fish in Clay

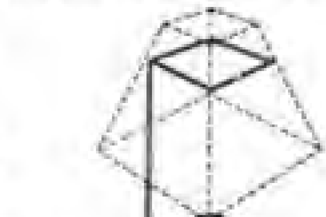
A clay-baked fish is so simply prepared, compared with cooking it in camp, that it will be hailed with delight. The best kind of clay to use for the purpose is the gray clay generally found along streams, but in the absence of this, ordinary red clay will answer. The fish is cleaned and washed, stuffed if desired, and sewed up in the ordinary way; the head of the fish may be left on. The clay is packed around the fish so that there will be a 2-in. thickness of it at all points, and it is then ready to be tucked into the fire. Previously, a hot hardwood fire has been kept going; ash is to be preferred because it produces hot coals that last a long time. It is generally a good idea to convert the evening campfire into a heap of coals for the purpose. The fish is placed at the bottom of the coals, covered, and left overnight. In the morning the coals are scraped away, and the hard-baked clay crust broken away with the camp hatchet, exposing the thoroughly cooked fish, savory and palatable to the last morsel. A 5 or 6-lb. fish makes an ideal bake.

A Candle-Shade Holder

From Popular Mechanics 1915

A holder for either round or square shades can be easily constructed from a piece of heavy copper wire to fit on a





Two Forms of Shade Holder Made of Copper Wire for a Candlestick

candlestick. One end of the wire is looped around the upper end of the candlestick, then bent so that the main part will be vertical. The top end is shaped into a circle 2 in. in diameter or a square having sides 2 in. long, as desired.

Aside from Hitler's National Socialist doctrines in that period, the German people then, before and since, have been close in culture and attitudes to Americans. They were a very stable people, for the most part.

Thorwald recounted an instance of gut-level survival, to which I'm afraid most Americans would act similarly.

As the Russians moved in, looting, raping and murdering civilians, there was this last German ship leaving a certain port, headed for an area the Russians wouldn't reach. (I don't remember the ship or the port, as I haven't seen the book in years).

Germans swarmed in huge crowds trying to board that last ship. The captain announced that only people with children could get on. As the word spread, people went around the town stealing children for use as boat tickets.

Many lucky adults actually threw their own children over the side to wives or husbands waiting 40 feet below on the dock. Most children who were caught, died from the impact. The great majority fell into the water or onto the dock itself.

Just as a sidelight, that packed ship was later sunk by the Russians, making it the greatest loss of civilian life in any single ship disaster.

If the Germans, supposedly the most disciplined people in the West, could act like that, what will you do when it's every man for himself?

THE GENE POOL & SEXUAL SURVIVAL

By Kurt Saxon

A deer herd is led by the ablest buck. He takes all the does and fights any challenging bachelor. Bachelors may never breed, but they stay, giving alarms and fighting off predators while the does feed in the guarded area. They are still in the gene pool. When the leader weakens or is killed, the best bachelor takes over.

The ablest wolf in a pack is usually the only breeder. Pack bachelors hunt and guard the leader, his mate and pups. Females born to the pack leave with the strongest bachelors and begin their own packs.

Sex among wild animals is only a driving urge to survive genetically. The male is not turned on unless there is a nearby female in heat. The urge being seasonal, the animals are peaceful for long periods between mating. Humans are not regulated by seasons so they are ready just about all the time.

Primitive groups of men were regulated basically the same as the deer herd or the wolf pack. The best man had all or most of the women to himself. But since the procreative urge was fairly constant among both sexes, there had to be rules, lest constant infighting destroy the group. Humans had to ritualize, traditionalize and rationalize sex.

The Bible is the most explicit record we have of primitive peoples; nomadic herdsmen and small village groups. Here is graphic evidence that primitive peoples replaced the animals' natural sexual restraints with the taboo.

These taboos were just as strong with primitives as biological regulation was with animals. The human bachelor, too, had to wait his turn for an available female. He could only find gratification through winning a female in battle or buying her from his chief.

When Jacob considered himself worthy to reproduce, he went to his third cousin, Laban and asked for pretty Rachel. The price was seven years of servitude. Then Laban gave him his older daughter, Leah, instead of Rachel, Genesis 29:21-26, saying he wanted to get rid of his firstborn first. Laban got Jacob to work still another seven years for Rachel.

As hard on Jacob as that was, it shows that he accepted the rigid sexual taboos of his culture. Like the animal bachelor, Jacob was resigned to celibacy until his mating was approved. As most men in his culture, he had to struggle to pass on his genes.

As agriculture developed and more people could survive with less effort, cities came into being. Here, there were not the controls faced by deer, wolves, and simple herdsmen like Jacob.

The city fathers had the best and the most females. Males without property

Drillpress Improvised from a Vise and Electric Motor

From Popular Mechanics 1932

Here is an improvised drillpress for the home workshop. The motor, fitted with a ¼-in. drill chuck, is screwed down on the bench in line with a vise as shown, so that closing of the latter pushes the work against the drill. This arrangement is quite satisfactory for odd jobs where the work does not justify the expense of a regular press.

Small Chuck on Electric Motor and a Vise Form Drillpress for Odd Jobs

DETECTOR INTRUDER

By Tommy Murphy

Electronics can be put to many uses in the situations that will confront a person in a survival situation. Electronics makes it easy to have a bunch of sentries to stand guard for you. An advance warning system can consist of simple materials, some thin copper wire, a few staples, some conductor wire, a battery and alarm, either visual or aural, or both. I prefer both as I do not want to be tied up by watching light. If the perimeter is penetrated, I want to know instantly about it.

I would suggest that a number of automobile headlights be rigged up on high beam and put in locations that will give you a circle of bright light. The sudden glare will blind an aggressor and give you an edge if the intrusion occurs at nighttime. You cluster the lights as it is quite possible that an attempt would be made to shoot them out. Then of course, that would pinpoint the location. Notice that I use a 12 volt car battery, car headlights, and as many other parts from automobiles as possible. There will be lots and lots of cars and trucks laying around to salvage from. Also the electrical system can be used in a homemade wind generator to keep those batteries charged.

Now if we are going to use electronic equipment in our little stronghold, it stands to reason that we should learn as much about it as possible. You could keep

or influence took the leavings for wives or had access to prostitutes. Prostitution may have been encouraged by the leaders to keep bachelors away from their harems. Homosexuality may also have become tolerated for the same reason.

Thus, the leaders controlled the gene pool, so did not feel threatened by the vices of common folk. At any rate, with the institution of cities, sex became associated with pleasure.

Sex was not fun to Jacob; it was just a relief of his natural urge. To his wives and concubines, it was only for the conception of children, a primitive woman's only chance for fulfillment and recognition.

The fact that Jacob didn't even know he was mating with Leah instead of Rachel, Gen. 29:25, shows that the act was as simple and one-sided as the sex act can be. This is reinforced by the tale of Judah and his daughter-in-law, Tamar (Gen. all of chapter 38). After the Lord killed two of her husbands, Tamar despaired of being got with child. She then played the prostitute and seduced Judah on his way to shear sheep.

Now, Tamar was around the house constantly, but Judah didn't recognize her when he mated with her. No kissing or foreplay. Just wham-bam-thank-you-maam. That was sex among primitives.

On the woman's part, there was no involvement. She was just a vessel; an incubator. In Deuteronomy 25:11, the law states that if a woman touches a man's "secrets", even in defense of her husband's life, her hand was to be cut off. This taboo concerning the male organs was just a reinforcement of a woman's non-involvement in the sex act.

Non-involvement for the female was essential since the husband was often away. Had she considered sex itself as pleasure, she might have been attracted to other men. So sex among primitives was only for relief and procreation. Only in the cities had sex become a way of life, rather than simply a part, and therefore a vice.

In primitive, close-knit societies, violations of sexual taboos had consequences understood by all. If a man's son took up with prostitutes or other men, his father was denied grandchildren. If a bachelor deer should choose the best young buck for a mate, when the lead buck was out who would fight for the does? A lesser qualified buck would pass on the genes while the prancing bucks fed with the girls. End of herd. If a bachelor wolf frisked with the next in line for succession as pack leader, on the death of the leader a lesser qualified bachelor would take over and the pack would die out. In Jacob's group, life was so hard and infant mortality was so high that no one could be spared from contributing to the gene pool. Had he took up with a fellow herdsman, he wouldn't have worked fourteen years to get Rachel and then the Christmas card business would never have had a chance.

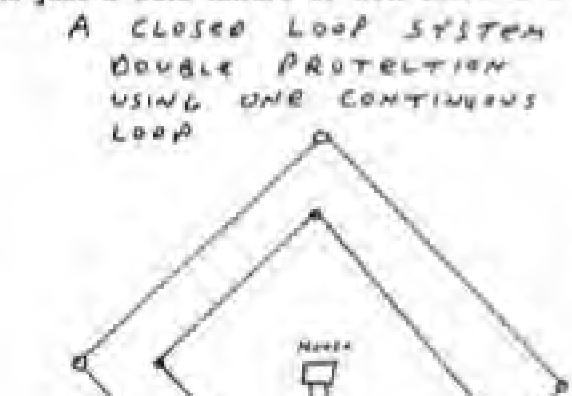
As primitives became less primitive and more children lived, it became easy for them to lose sight of the importance of the gene pool. So elders set about codifying the sexual taboos into law. But since sex is usually done in private, the laws would have been hard to enforce. The best method known to them of enforcing genetically proper sexual behavior was to say that the laws were given and enforced by the local diety. This worked, after a fashion, but as people merged and traded gods back and forth, the sex laws became adulterated and their real purpose was generally lost sight of. This was especially so in the cities.

Enforcement of the sex laws was in a large part responsible for the Israelites' antagonism to city folk, their loose ways and their many gods. They feared any influence by foreigners and their often more sexually liberal gods.

Today's people seem ignorant of the natural laws concerning their gene pool. This is especially so in this country, where homosexuality is promoted as a purely private matter and an individual right.

Opposing this growing attitude is Anita Bryant and her Save Our Children campaign. I admire her stand and that of all her supporters. But her main emphasis seems to be on religion. Primitives have almost universally been anti-homosexual, regardless of what gods they worshipped. To ascribe a lots of spares but the better way is to learn to keep what you have going. If you are going to use a survival tool, learn as much about it as you can. Electronics for our use does not have to be complex or difficult. The simpler something is, the less parts there are to go bad. With this perimeter detection device (anyone can make it) yet it works as well or maybe better than many sophisticated warning devices. The important thing to remember is secrecy in the installation. Hide the trip wires well.

The major disadvantage is that the circuit is live and uses battery power all the while it is in operation. However, the current consumption is small. The thin copperwire is strung around the area you wish to have covered in a double-loop, so that you have double protection just in case someone gets by the first section of wire. The wire can be stapled to stakes or trees throughout the perimeter area. As long as the light on the system is on, then the system is alright. When the light goes out, the buzzer will sound, and to tell if it is just a bulb failure or not, there is a



built-in check for light failure. Note that six volt bulbs are used in the system, because of the voltage drop that occurs in the long run of warning wire.

The relay is of the type that uses very little current and is quite sensitive. The relay is held in a pulled-in position by the voltage through the system. If a break occurs, the relay will drop out and cause the buzzer to sound as well as the indicator light to go out.

Now you are using electronics, in a simple form but very effective. With just the use of your hands and a few bucks, you

purely genetic law to a specific god obscures the purpose of the law.

Anita says that since homosexuals can't reproduce, they must recruit. This is her most valid point and conforms to the law governing the gene pool. Since recruitment is epidemic in our time, this point should be elaborated on almost to the exclusion of other arguments. But in quoting scripture so often, she makes homosexuality a Fundamentalist Christian issue. People who aren't Fundamentalist Christians and have no concept of the gene pool, simply consider anti-homosexuality to be religious bigotry.

That this is not at all the case is proven by the attitude toward homosexuality by Russia and Red China; communists and therefore atheists. In Russia, homosexuals are sent away, seldom to be heard of again. In China, homosexual seduction is punishable by death, as it should be here.

As a Survivalist, you may consider our culture too far gone to be concerned with a bunch of perverts taking themselves out of the gene pool. You may believe they are natural defectives and so the species would be better off without their genes. Also, with so many more people than the nation can properly handle, the less children born, the better.

The truth is, however, that homosexuals are not necessarily natural defectives. And concerning the surplus population, to call robbing the gene pool "birth control" is insane.

If homosexuals preyed only on inferiors there would be some positive results. But whereas the normal male wants the prettiest, healthiest girl, the homosexual is attracted to the best looking, healthiest boys around him.

Psychologists have found no evidence that any virgin is naturally oriented toward homosexuality. There is no such thing as a born homosexual. Homosexuality is a learned preference. Also learned are the effeminate mannerisms and speech patterns.

Homosexual seduction usually occurs when a young person has passed puberty but as yet has had no real sexual experience with another. He is often lonely, confused and alienated. He is then befriended by a homosexual and seduced. Since it's his only sexual experience and part of a friendly relationship, it can become his preference, and then he's out of the gene pool.

Not all youngsters are approached. Not all attempted seductions are consummated. Often, a lad is approached by a stranger and given a particularly disgusting proposition or is offended by unwelcome physical contact. In his ignorance he believes there was something about him that told the pervert he would be receptive. Doubting himself from then on and wanting to remove any such doubts from the minds of others, he becomes a "queer baiter". The queer baiter often contributes to homosexuality. Not content to insult obvious homosexuals, he will taunt a virgin lad with "fairy", "sissy", etc., because the boy may be gentler and quieter than other boys. If the taunting gets to the boy and makes him doubt himself, he may be a pushover for the first homosexual he meets. A father who nags his son to go out for sports and be a "man", often drives the kid right into the arms of the coach.

Homosexuality is indeed epidemic in our land. Los Angeles alone is reputed to have at least 30,000 or more little boy prostitutes, some preteeners. Homosexuals say they aren't interested in little boys. They would have you believe the real culprits are child molesters—pedophiles.

These wretched pedophiles sometimes kill their victims and most often injure them physically and/or mentally. The victim of the child molester is usually traumatized and so is hardly likely to seek more of the same treatment.

No, the 30,000 little boy prostitutes in Los Angeles and elsewhere were seduced by predatory homosexuals who treated them gently and paid them. And 30,000 little boy prostitutes couldn't get by in the trade without a large clientele of active homosexuals who do indeed like little boys. There are at least 200,000 homosexuals in Los Angeles County and over 100,000 in San Francisco. Homosexuality is addictive and since it is spreading like a plague, you might even say it's contageous.

get a security system to surround your entire house. A system in your home is good of course, but that means that they are getting mightily close. This way you have a little time to give them a greeting.

PARTS LIST

I1—ALARM LIGHT—Use 6 volt bulb in system due to voltage drop through loop. Radio Shack #272-318 or 272-319 bulbs. Light—Radio Shack #272-324 or 272-325.

R1—RESISTOR—82 OHM, Radio Shack #271-008, ½ watt.

S1—PUSH BUTTON SWITCH—Radio Shack #275-1547, normally open.

RELAY—Miniature type, Radio Shack #275-230 or 275-004.

B1—BUZZER—Radio Shack #273-051.

BATTERY—Any 12 volt—prefer automobile.

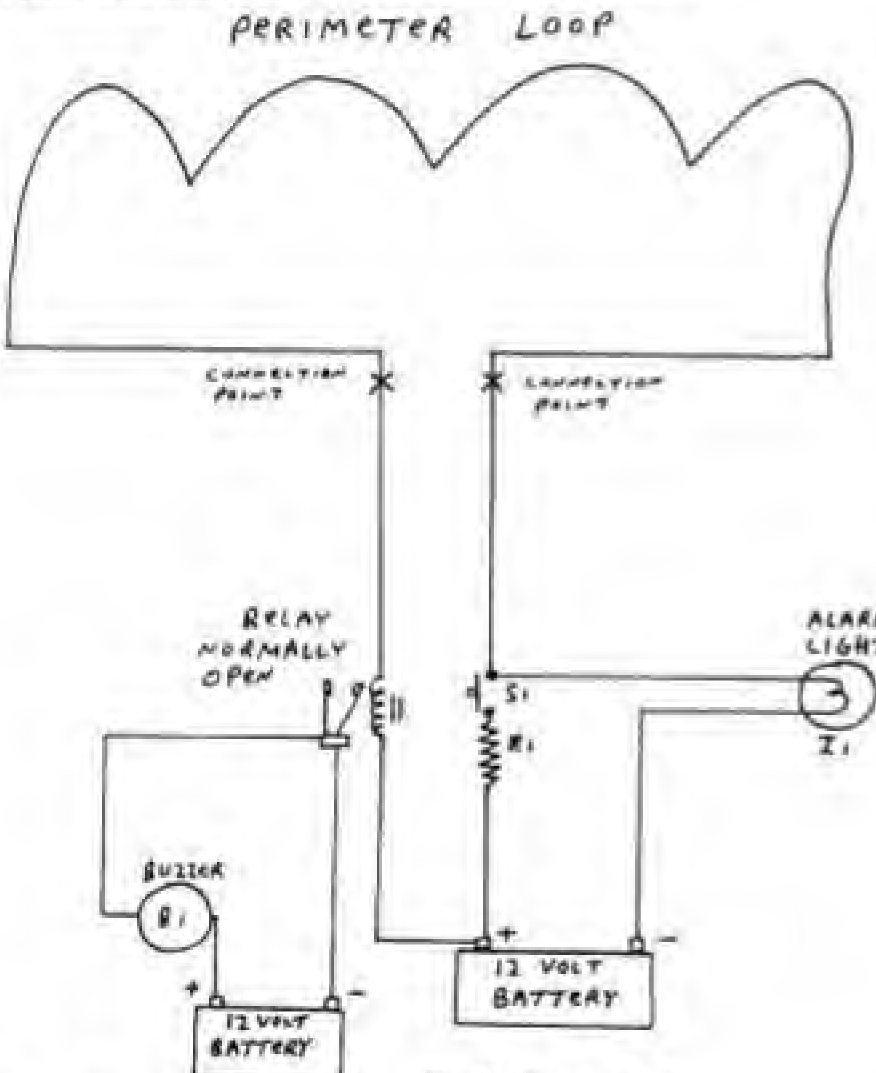
WIRE—#26, Radio Shack #278-005.

With the new tolerance toward this vice, every child is more vulnerable now. Especially when he sees perverts parading across the TV screen to the cheers of Liberal "heterosexuals".

One such Liberal is Jim Dunbar, a San Francisco talk show host. A while back, I heard him say he was encouraging his fifteen-year-old son to be tolerant of homosexuals. I was glad to hear him say that. Anyone who has done as much as Jim Dunbar to spread the acceptance of perversion deserves to have his line die out.

On the same station, I saw Chip Carter come out publicly endorsing "Gay Rights." When the son of the president of the United States openly approves faggotry, who then can say it's wrong?

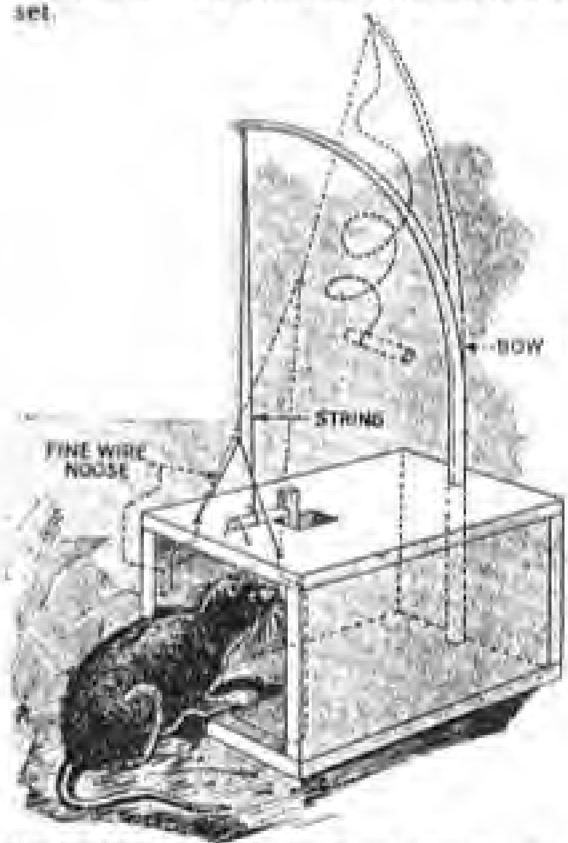
There is little you can do about the national gene pool. But you must guard yoer own family gene pool. You should tell your youngsters that if any adult gets overly friendly and tries to pet or fondle them, they should come home and tell you. Now with homosexuals agitating to teach as identifiable perverts, our national gene pool is in even more danger. If I had a kid whose teacher was an admitted homosexual, I'd see that teacher on the road or under the ground.



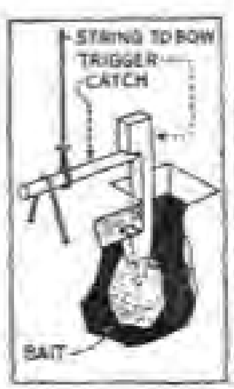
How to Make a Bow Trap

From Popular Mechanics 1928

A bow trap is easily made and is very effective for killing rats and mice. To make one suitable for rats, nail together four boards, 8 in. long and 5 in. wide. Drill two holes, 1 in. from one end, to hold the bow as shown. Also cut an opening, 2½ in. from the opposite end, for the trigger. Drill two holes, 2 in. in front of the trigger hole, for the noose, which should be made of fine wire. The bow is then attached; it should be quite supple and strong. Whittle out the trigger and catch, and nail a small loop of string to the box to hold down one end of the catch, the trigger being used to hold the other end. Tie strings from the bow to the noose catch as indicated, carefully taking up all slack from the noose. Adjust the catch string so that the noose will fill the space in the box opening when the trap is set.



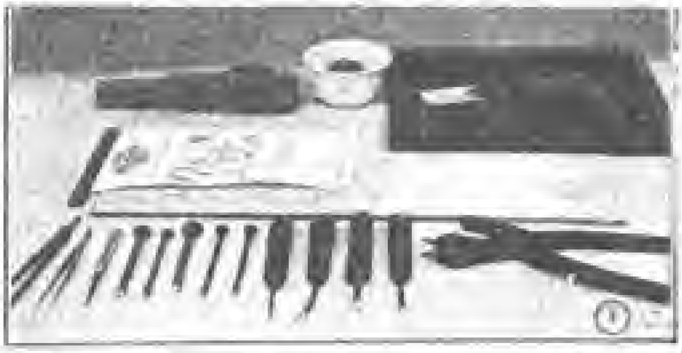
Any Boy Can Make This Bow Trap for Catching Rats and Mice



BORAX DELAYS SETTING OF PLASTER OF PARIS

PLASTER of Paris may be used for patching cracked casts and similar work without undue haste if powdered borax is added in the proportions of 2 oz. to 1 lb. of plaster. Mix the powders well in their dry state and then add cold water until the resultant paste is of the consistency desired. The plaster will take almost twice as long as usual to become set and unworkable. This is a formula often used by dentists and doctors.

It's Easy to Tool LEATHER



DECORATIVE leather tooling is so simple that the veriest amateur can do a pleasing job. Although the work can be done with only a nutpick, a small thumb-shaped modeling tool will greatly improve the original job by bringing it into sharper relief, and, as the beginner gains skill, an assortment of homemade stamping dies, punches, and other tools, as shown in Fig. 1, may be added to obtain a variety of pleasing designs.

For a billfold, only four tools are required: a nutpick, a modeler, a stamping die for the borders and a leather punch. The most satisfactory material is English tooling calf, which has a velvety surface and retains impressions readily. Ooze calfskin or split cowhide with ooze finish are also suitable. A test of proper leather is to indent it with the thumb nail. If the impression is retained, the material is suitable. After obtaining the leather, lay out the design shown, or any other of your selection, on a sheet of paper. In choosing design, pick one in which the lines are not too intricate nor too close together. It is best to cut the leather oversize and trim it down after the tooling has been done, as the beginner may pull the piece out of true shape. Besides, a little extra leather permits the use of thumbtacks or paper clips in tracing, without marring the edges. Get a piece of heavy plate glass, such as part of a windshield, or a slab of smooth slate or polished marble, upon which to lay the work. In tracing the penciled design, you can fasten the work to a smooth board with thumbtacks. Either a hard pencil or a nutpick is suitable for tracing, leaving the design plainly visible on the leather. If the point of the nutpick is sharp and has a tendency to scratch, round it off slightly with a file and smooth with fine emery paper or an oilstone. There should not be the slightest roughness on any of the tools. A modeler can be made by cutting off $2\frac{1}{2}$ in. from the pointed end of a spike, as in Fig. 7, flattening and bending the end, and then grinding it round, somewhat in the shape of a tiny thumb. Set it in a hardwood handle, Fig. 8, so that the end extends about $1\frac{1}{4}$ in. While making this tool, you may as well add a pebbling die and a flower stamp, as shown in Fig. 8, as they will come in handy on subsequent work. The pebbling die is merely the end of a flattened bolt or spike, grooved with a three-cornered file. The flower design is made in a similar manner. Other dies in great variety can be added from time to time, among which a star is often useful.

With the design traced on the leather, deepen the lines with the nutpick as shown in Fig. 2, having first moistened the leather with a wet sponge, and keep it moist but not too wet as you proceed with the work. After the lines have been indented, use the modeler to press down the leather around the main outlines of the design and to work it into relief, as shown in Fig. 7. Do not attempt this, however, where lines are close together, as in the lines of the lion's mane, in petals of flowers and leaves, etc. The background around the figure can either be pebbled with the nutpick or with the pebbling tool. For large surfaces, the latter makes for less heavy work, although the former may perhaps give a more pleasing effect. After the tooling has been completed, cut the piece to finished size, laying it flat on a board and using a sharp, thin knifeblade against a metal rule or straightedge.

SQUARES
FIG. 4

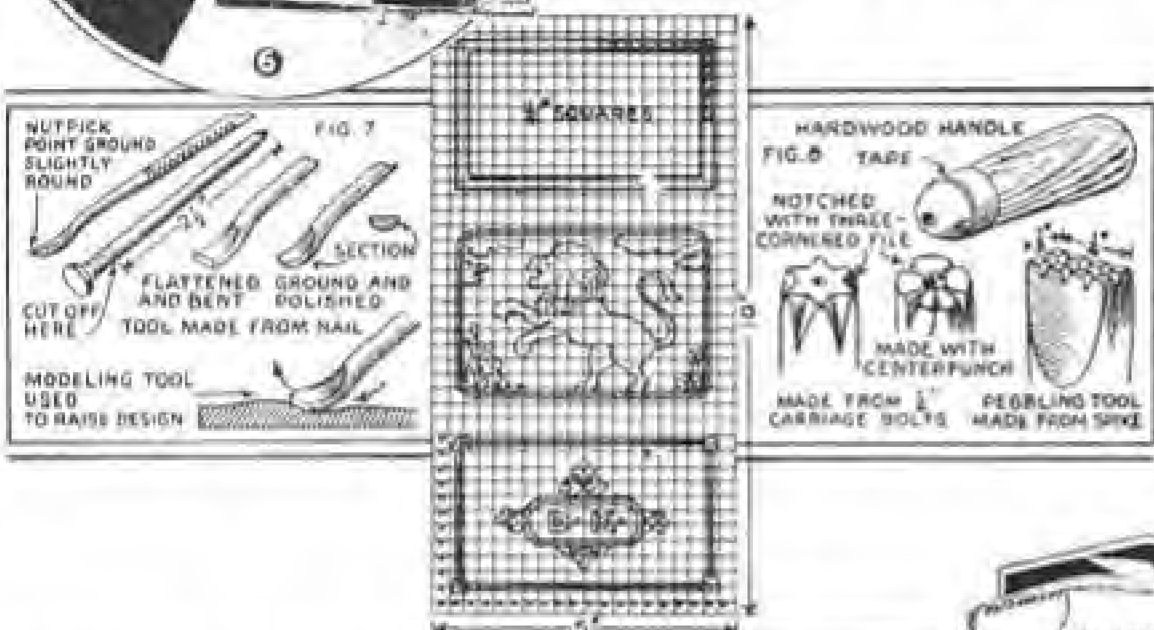
From Popular Mechanics 1932

For a billfold, cut a plain piece the same size as the tooled piece. Score the tooled piece lightly where it is to be folded, then fold the two pieces along this line, using the hardwood creaser shown in Fig. 10. Note that the inner piece will then extend slightly beyond the outside section; trim the former flush. When this is done, the billfold will fold naturally, without a bulge on the inside piece. With a pair of dividers, or a rule and sharp pencil, lay out centers of the holes for the lacing on the tooled piece. They should not be over $\frac{1}{4}$ in. apart on centers and $\frac{1}{8}$ in. from the edge. Use a leather punch of about $\frac{3}{32}$-in. diameter, and punch holes in the inner and outer pieces, as well as the card-pocket flats, at the same time so that all holes will register. If you cannot buy thongs cut to suitable size from the shoemaker or leather-supply house, lay a long strip of calfskin on a smooth board, with

Your Billfold, Purse or Belt Can Be Greatly Improved by Simple Designs Brought into Relief with a Few Homemade Tools

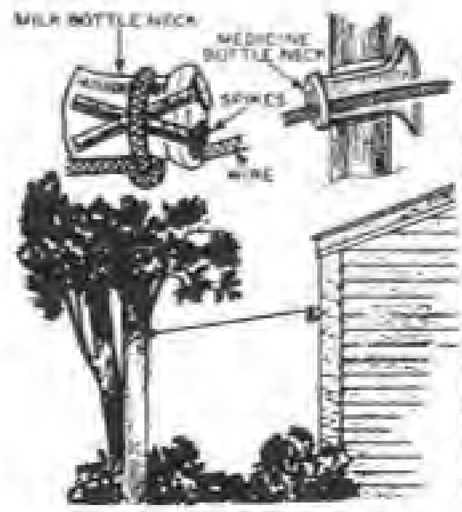
entire piece is embossed as shown in Fig. 5. The petals and leaves can be brought into very prominent relief by using an embossing tool around the edges, as in Figs. 6 and 12. This tool consists of a spike with the end flattened, bent to a curve and then ground to the shape shown. It is worked around borders of the design and tapped with a cowhide-covered stick, as hammer blows would be too sharp for this work. The depressions can be made even deeper by first using the pebbling tool and then smoothing out the marks with the flat-surfaced embossing tool. After the embossing has been completed, a buckle and straps should be sewn on by a cobbler to insure a first-class job. The background of the design can then be darkened with black leather color.

An endless number of useful and attractive objects can be made by the amateur as he gains experience.



the grain, and run the knife along the edge of a steel ruler, cutting off strips about 3/16 or ¼ in. wide. Splicing can be done by tapering the ends ¼ in. and using leather cement. The lacing is shown in Fig. 9. At the corners, the thong should be passed through the hole twice.

Embossing a belt is not at all difficult, but requires time and patience. Of course, it can be tooled by the method just described, but the embossing will not be as distinct as when a die is used. Buy a strap of cowhide, ooze finish, about 1¼ in. wide and the required length, with an extra 5-in. length of heavier cowhide to serve as a die. Lay out the flower design, as shown in Fig. 4, on the latter piece and cut it in outline with an incising tool, which is ground from a round file, has a 30° V-shaped edge and leaves a very distinct incision. See Fig. 11. Hold the tool with a firm grip nearly vertical, cutting to about 1/16 in. or more in depth. Next lay the belt strap flat on the marble or glass slab, moisten it, place the die over it and pound with a hammer as in Fig. 13. This presses the belt leather down between the incisions of the die, and forces it up along the lines of the design, leaving them in sharp relief. The die pattern is used successively along the length of the belt until the



Bottlenecks Make Serviceable Insulators

BOTTLE necks, being made of glass, are ideal for insulators when secured firmly to a pole or inserted through a wall. The easiest method for separating the neck from the body of the bottle is by the use of a gas soaked twine, as described in the handikink item, "Emergency Ice Bag from Inner Tube, Mason Jar." To make an outdoor suspension insulator use a milk bottle neck, secured to the pole with two nails driven in as shown in the accompanying drawing. For a lead-in insulator, the neck of a medicine bottle serves best. It should be slanted downward as illustrated. A little putty will hold the glass firm in the wall.–

How Much Will a Mother Love Her Baby?

Cleveland *New York Times*

Most of the time at the Rainbow Babies' and Children's Hospital here, the doctors talk about children and their mothers. But sometimes, they talk about goats.

Goats provide an extreme example of how nature makes sure that offspring are protected. In the first ten minutes of her kid's life, a goat mother identifies it as her own and becomes firmly attached to it. But if the kid is removed for those early minutes, the goat mother will reject it.

Two pediatricians — Dr. Marshall Klaus and Dr. John Kennell — assert that something similar, although less extreme, happens when humans are born.

From their own research and clinical experience and from studies their work has spurred elsewhere, Klaus and Kennell have concluded that the contact of human mother and child in the first hours of a baby's life — perhaps in the first minutes — may have a long-lasting effect on how attached the mother will be to the child.

Although a mother's attachment nearly always does occur anyway, Klaus and Kennell say that in many women it may not form as easily or as obviously without extended early periods with the baby.

They say the findings are especially important for mothers who are more likely to have difficulty becoming close to their babies — because their children are malformed, premature or unwanted.

The doctors, who are both professors of pediatrics at Case Western Reserve University, which is associated with the Rainbow hospital, say that in one carefully controlled experiment they studied mothers who had had hours of early contact with their babies and compared them with others who have had only brief contact.

A month after the children are born, mothers who have had more early contact with them are demonstrably more affectionate — they fondle their children and gaze into their eyes more than do the other mothers.

At one year, when these mothers are observed at the doctor's office, the same affectionate ones hover about their children more, soothing them. They are less eager to leave their children with anyone.

At two years, they speak to the children with a greater number of words and questions and with fewer commands than do the other mothers — a finding that could have implications for intellectual development.

Kennell says the studies indicate that "the earlier you put mother and child together for extended periods, the more powerful the effects will be." Increasing contact any time in the first three days appears to be effective. But both Kennell and Klaus are convinced that there is something especially important about the time mother and child spend together in the first hour or 90 minutes after birth.

During that time, they say, the baby and mother both seem to be in an unusual state of mutual receptivity. The mother, if she has not been made drowsy by drugs, is at the peak of excitement. At the same time, the baby is more alert in the first hour than he will be later. The baby's eyes may be open for as much as 45 minutes; later they will be closed 90 per cent of the time.

The baby's wakefulness is important, Klaus says, "because the mother can't make love to a baby unless the baby makes love to her."

The lovemaking the pediatricians describe is a kind of primeval dance. The mother gazes into the infant's eyes for increasingly long periods of time, all the while talking to the child in a high-pitched voice — because the mother is somehow aware that babies are more receptive to higher pitches.

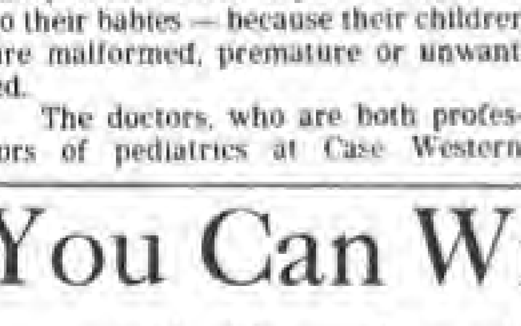
The voice is the dance music. The baby's movements often synchronize exactly with the rhythm (slow-motion pictures reveal an eerie precision in the infant's body movements as the mother talks). And the infant is following the mother's face, too.

Since early contact appears to be powerful in affecting the behavior of mothers, say Klaus and Kennel, why make the attachments more difficult to form by using procedures that keep mother and child apart?

So they support the recent trend toward "family-centered" childbirth that allows parent and child to be together immediately.

You Can Write on Metal

with this easily made vibrating electric pencil



A battery or a small transformer supplies the current required to operate the pencil

By KENDALL FORD

TOOLS and other metal objects may be permanently marked for identification with a homemade vibrating electric pencil of the type illustrated. It may be easily made from odds and ends.

The handle is shaped as in Fig. 1 from a piece of close-grained, round wood 3/4 in. in diameter and 6 in. long. A piece of maple dowel forms an excellent handle, but if it is not available, a satisfactory substitute may be made from an old broom handle. Drill a 5/8-in. hole in the large end of the handle to a depth of 1 1/4 in., and a 5/32-in. hole to a further depth of 3/8 in., as shown. Then cut a recess in one side of the handle for the armature spring.

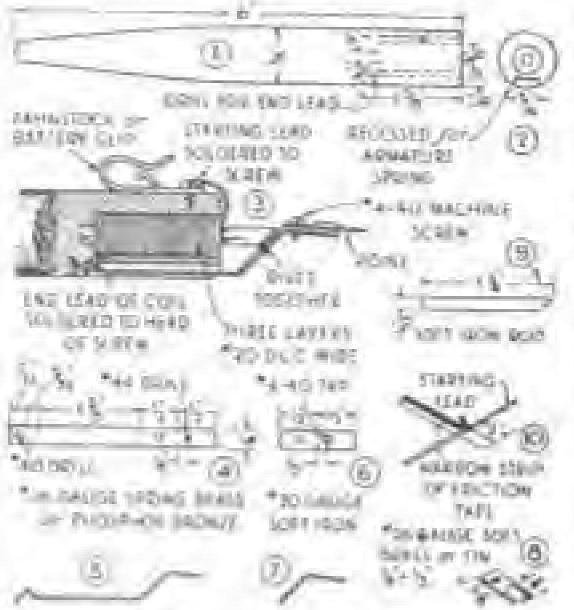
Obtain a piece of soft iron rod, 5/32 in. in diameter, and cut to the size and shape indicated in Fig. 9. A 12-penny nail has an approximate diameter of 5/32 in. and will serve satisfactorily for this piece.

Approximately 6 ft. of No. 20 double cotton-covered wire will be required for the coil. Place a narrow strip of friction tape along the iron rod, or core, and start the winding 1/2 in. from the pointed end. The end of the wire is placed over the tape (Fig. 10), after which the end of the tape is folded back over the wire. When the first turn of the coil is completed, it will pass over the folded end of the tape and secure the starting lead firmly in place.

Continue winding until within 1/8 in. of the opposite end of the core. Then fold over the tape and begin the second layer of the coil. As the second layer is started, place a narrow strip of friction tape on the opposite side of the core and proceed as in winding the first layer. Three layers of wire should be wound on the core, with the ends brought out as shown in Fig. 3. Shellac or paint the coil to serve as a binder.

Obtain a piece of No. 26 gauge spring brass or phosphor bronze, 1/4 in. wide and 2-1/4 in. long. Mark off sections and drill as shown in Fig. 4. This piece, together with those shown in Figs. 6 and 8, serves as the armature and point holder. Drill all the holes with a No. 40 drill, except where a No. 44 drill is indicated. Shape the spring as shown in Fig. 5. Cut a piece of No. 20 gauge soft iron to the size shown in Fig. 6, drill and thread as indicated, and bend to the shape shown in Fig. 7. Rivet pieces 5 and 7 together with a piece of soft iron wire, as shown in Fig. 3.

A piece of No. 26 gauge soft brass or tin should now be cut to the size shown in Fig. 8. Drill as indicated and bend so as to form a groove for holding the needle or copper point securely to the armature. Secure the needle holder to the end of the armature with a No. 4-40 machine screw.



The handle, the assembled working point, and details of armature, spring, and other parts

Insert the coil in the handle and bring the starting lead to a small Fahnstock or battery clip, as shown in Fig. 3. A clip taken from an old radio "B" battery will serve. When securing the clip to the wooden handle, take care that the wood screw does not extend into the coil. The end lead of the coil should be brought out through a small hole previously drilled from the spring recess to the end of the large hole in the handle.

Fasten the armature to the handle with a small wood screw, and solder the end lead of the coil to the screw, as shown in Fig. 3. Glue a piece of tape or thin cardboard over the spring recess, and paint the handle a suitable color.

The point may be an old phonograph needle or a pointed piece of copper wire, but since the effect of each varies on different metals, it is advisable to experiment with both. In using the pencil, one wire from the source of supply is connected to the article to be marked, and the other wire is connected to the clip on the pencil. From four to six volts will be required to operate the pencil, and this voltage may be obtained from either a battery or a small transformer. The pressure applied to the pencil should not be so heavy that it will not allow a free movement of the vibrator.

SURVIVE IN THE CITY

By Boyd Hill

There are a great number of people who, when the balloon goes up, can not or will not get out of the bigger cities. Take me, for instance; I'm old enough to be your grandfather, severely damaged physically, totally dependent on special medicines, and unable to get out or stay out in the boondocks to survive.

Yet I intend to survive. Here's how......

Not everybody can bug out when the time comes for rioting and looting in the cities. The elderly and the ill are chained to urban existance. Yet even under the worst conditions they can give themselves a better than 50 % chance of coming through alive and well.

But first of all dismiss any thoughts of nuclear problems. Chances are a thousand to one that nukes will be like gas--much feared, much talked about, but never used--in major conflicts, that is--because, like biological warfare, it can rebound too terribly on the first user. For that matter, if it ever comes to such bombings just forget survival planning. Living through it will be a matter of luck, and nothing else.

Civil disturbances are a different matter. They have happened already, and will do so, more and worse, in the future. They also will spread out into the countryside, particularly so long as gasoline is available.

But remember this: No matter how terrible the conditions may be, they cannot last forever. If the government is strong enough, it will put down all the trouble inside of ten days. If the governmental force is absent, the disturbances will burn themselves out inside of three weeks. So if you are prepared to live isolated and protected for only 20 days, you will almost certainly survive the violence.

Also remember that civil disturbances almost always give plenty of warning. Tension builds up, and there are many small riots before the big one. Even so violent a time as Watts lasted much less than a week. Anybody can survive a full week without any preparation, so long as he has a home that cannot be burned out through misadventure. Just stay inside with the door locked and barricaded, and all lights out all the time, and wait until your radio tells you the All Clear is in effect.

A toilet tank and bowl holds enough clean, sterilized water (it's the same that comes out of your kitchen tap) to last two people comfortably for a week, for drinking, cooking and scanty washing purposes. In the hot South Pacific in War Two the GI's managed perfectly well on two canteensfull two quarts- each day. Anybody who is worried about a little contamination in a toilet bowl and tank can put a teaspoon of Chlorox or Purex in each, and be thereby easy in the mind.

Food really is no short-term problem. Practically everybody above the total poverty level has far more edibles stowed on their shelves than they realize. And besides, face up to it; a person can go for 30 days without--even sometimes to their physical improvement. Just five days of canned edibles on the shelves can be stretched, by quarter-rations, into 20 man-days of food.

Sanitation will be most important when one is cut off from the world and running water. But the solution is cheap and simple. Get an inexpensive plastic bucket with a tight sealing lid, a dozen or so strong plastic bags larger than the bucket, a bottle **of deodorant-disinfectant such as Pine-Sol, and a few of the wire "twisters" used to close breadbags or other plastic containers. Put a bag in the bucket, lapping the b ag's edges over the rim of the bucket. After using, put in a squirt of the disinfectant, twist the bag closed and seal with the twister wire, and put the top on the bucket. Each new use, untwist the bag top, then re-seal. A dozen bags will last two people more than a month. So it may smell a little? That's better than being dead. Dead people smell a lot--and a lot worse, for that matter.**

Riots are not continuous, nor do they stay in one location. They flare up and down, and move from place to place. When the trouble dies down around your place, join the looters or the lawful, to augment your necessary supplies of water, food, disinfectant, ammunition, medicine, or whatever.

And if the edibles have been swept clean from your market, look in the pet food section. Canned or dry cat or dog food--along with dog biscuits-- are nutritiious provender and some of them (so I'm

told) are reasonable tasty.

Being ready takes little time or money. Have, or be able to get, containers for 10 gallons of water per person; have your sanitary bucket, bags and disinfectant stowed under the sink; keep a week's supply of canned goods on hand, and a bag or two of dry dog food.

Be able to close your door securely. Get a doxen lag screws and, when the time comes, drill the door so it can be screwed shut all the way around from the inside.

Make up a sign on yellow paper or cardboard; if you have access to an IBM Selectric typewriter you can prepare a very official document reading:

STAY OUT! DANGER!
QUARANTINE
This dwelling has been exposed to BUBONIC PLAGUE death. Do not open until fumigated.
/S/ Joseph Blow, MD
JOSEPH BLOW, MD
CITY HEALTH OFFICER

Put this on the outside of your door with thumbtacks or tape, and it will probably be better than a barricade against prowlers.

So lock yourself in, keep your lights off, don't try to cook, don't go near the windows unless they are shaded, and just settle down to sweat it out. Chances are excellent that the disturbances will expire before you do.

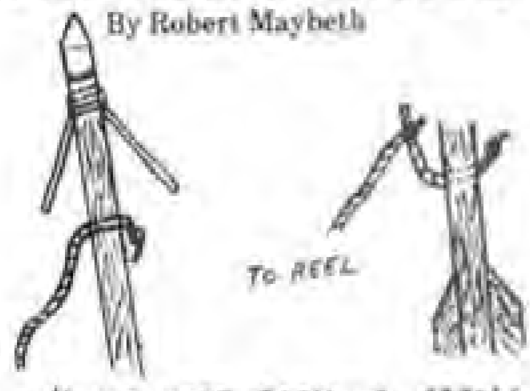
SCOTTISH SLING STICK

Take a wooden stick, about a half-inch thick. Cut a flat spot about an inch from the top. Tie a soft leather pouch to the flattened tip, and run a looped thong from the pouch to about six inches from the other end. Hold a small rock or such in the pouch, against the flat spot of the wood, holding the rock in place by tension in the thumb holding the other end of the stick.

Swing the thing as pleases you best, and release by slacking your thumb. These sticks can be made as long as one likes, with an increasing power and range. However, if they are much longer than about 14 inches, after a few dozen casts you'll develop a sore arm and shoulder you'll regret for a long time.

HUNTING FISH WITH A BOW

By Robert Maybeth



HOME-MADE FISHING ARROW

For thousands of years, men have been fishing with bows. In some countries, bowfishing predated the rod and reel. Even today, bowfishing still has a place in these days of graphite rods and computer designed lures. Whereas rod and reel fishing is a largely passive sport, bowfishing allows you to actually hunt your fish, rather than waiting for it to come to you.

All that a bowfishing rig consists of is a reel or other device attached to the bow to hold the line, and a barbed arrow attached to the line.

Some states permit archers to take the so-called "rough" fish, while other states forbid bowfishing entirely. It's always best to check your local laws, lest you find your gear confiscated by an uncooperative game warden.

If you don't already have a bow, get a good target or hunting model with at least a 30 pound draw weight. You won't need a powerful hunting model as the shooting range is nearly always under ten yards.

In the equipment category, the next thing to get is a reel and line. Sporting goods stores and mail order houses sell reels for as little as three dollars, including line and the wire frame you tape to your bow below the handgrip. It's easy to make your own, though. You don't even have to use a reel; coiling your line in a plastic drinking cup works fine. A paper clip holds the line (usually about 75 yards worth) in the cup until the arrow is shot. The line should be at least 60 pound test, as the arrow always comes to the end of the line with a great yank that will snap weaker line. Be sure to tie the end of the line to the bow.

The best (and most expensive) fishing arrows are made with shafts of solid aluminum or glass. They are best because of their lack of bouyancy, which gives them more hitting power than wood or hollow aluminum. If you're hard up for cash, it's okay to use wood arrows. But they will deflect more and hit with less force.

You can buy barbed arrows at the sporting goods store, but it's much cheaper to make them. Just sharpen the head of a regular field point, then drill a hole through the shaft an inch below the tip. Insert some stiff wire and bend it a single turn around the shaft. Lastly, bend the protruding ends upwards and snip the excess wire to complete the barb.

It is open to debate whether fishing arrows need fletching or not. The short range involved usually negates any stabilizing effect feathers might have; nevertheless, some bowfishermen swear by them anyway. It's your choice. If you opt for fletching, there are sprays available to waterproof the arrow's feathers.

About the best way to attach the line to the arrow is to drill a couple holes through the arrow's shaft—one a little behind the tip, another near the arrow's end, below the fletching. The line goes through both holes, resulting in a more stable flight than if you had just used a single hole.

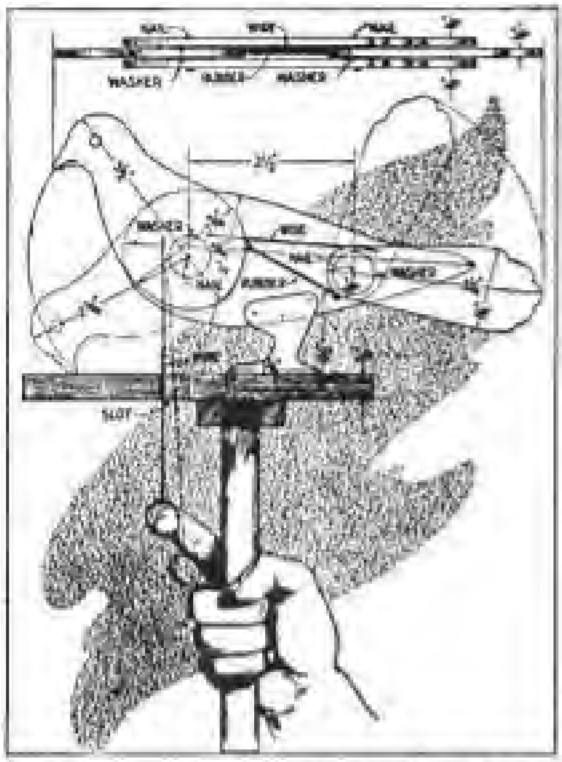
Most states that don't entirely prohibit bowfishing allow archers to take "rough" fish—gar, eel, suckers, mudfish and carp. Carp is the bowfisherman's favorite prey and is found in waters all over the U.S. They can be stalked, like deer, or shot from a pier or boat. Whichever method you use, get as close as you can before the shot.

Another favorite prey are frogs. More common than carp, they are small and elusive targets but stay on the surface for minutes at a time. For instructions on preparing them for eating, see Jim and Stephanie Watters' article on page 190, #4. I doubt if you will run into any problems with your local Fish and Game man while hunting frogs. It beats shooting them with a shotgun, anyway.

The most pressing problem in bowfishing is light refraction. Because of it, fish look closer to the surface than they actually are. Also, an arrow starts deflecting upwards the moment it hits the water. Therefore, you'll have to aim below your target in order to hit it. Practice with weighted balloons in shallow water before you go fishing—it'll pay off at dinner time.

Mechanical Toy Pigeon Made of Wood
Popular Mechanics 1919

When the head of the mechanical pigeon is lowered the tail rises, and



Draw on the Wire and the Head and Tail Bob Up and Down

the reverse. It is constructed as follows: Make paper patterns for the parts, which consist of two body pieces, a head, a tail, and the foot piece. The shape of the parts is shown in the sketch, the front body piece being removed to show the connections of the rubber and wire controlling the movements. The view above shows the fastening of the parts with nails. The main sizes of the parts, which are made of 1/8 to 1/4-in. soft wood, are: head, 1 3/4 by 3 1/2 in.; body, 2 by 5 1/4 in.; tail, 1 1/4 by 3 1/4 in.; foot piece, 1 3/8 by 1 1/2 in. Mark the shapes on the wood, cut them out, and mount them, with a rubber band connecting the head and tail, as shown. Nail the foot piece between the body pieces, and pivot the head and tail on nails. Connect the head with a wire, having a loop on one end. Make the holder, and cut a slot into it for the draw wire, operated with the finger.

A TOY HORSE THAT WALKS
Popular Mechanics, 1919

This toy, amusing for the youngsters, and their elders as well, will repay one for the making of it. Use a cigar box for the carriage, making it about 10 in. high, and shape it in the design shown. Nail a piece of wood, 1/8 by 2 by 4 in. wide, on each side of the carriage, and drill 1/8-in. holes in them for the axle. For the horse, take a piece of wood, 1/2 by 4 by 6 in. long, and draw an outline of the head, neck, and body. Cut this out and drill 1/8-in. holes where the legs are at-

FIRST PRINTING OF "THE NIGHT BEFORE CHRISTMAS" IN A PERIODICAL

HARPER'S NEW MONTHLY MAGAZINE

NO. XCI.—DECEMBER, 1857.—VOL. XVI.

A Christmas Garland of American Poems.

From "THE POETS OF THE NINETEENTH CENTURY."
8vo. Superbly Illustrated. Harper & Brothers.

A VISIT FROM SAINT NICHOLAS.

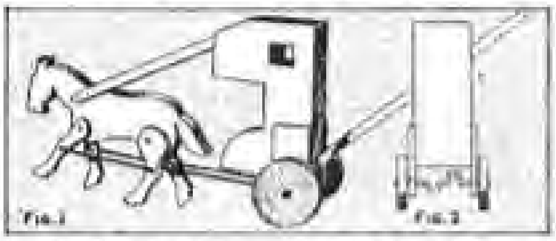
CLEMENT C. MOORE.

'TWAS the night before Christmas, when all through the house
 Not a creature was stirring, not even a mouse;
The stockings were hung by the chimney with care,
In hopes that St. Nicholas soon would be there;
The children were nestled all snug in their beds,
While visions of sugar-plums danced in their heads;
And Mamma in her 'kerchief, and I in my cap,

 THE SURVIVOR Vol. 2

tached.

Cut the legs as shown, about 3½ in. long. Attach them with small bolts, or rivets, allowing space to move freely. The wheels are made of pine, ½ in. thick and 3 in. in diameter. The axle is made of $\frac{3}{16}$-in. wire bent to the shape indicated, ½ in. at each offset. Fit the wheels on the axle tightly, so as not to turn on it, the axle turning in the pieces nailed to the sides of the carriage. The horse is attached to the top of the carriage by a strip of wood. A 3-ft. wooden handle is attached to the back of carriage to guide it. Wires



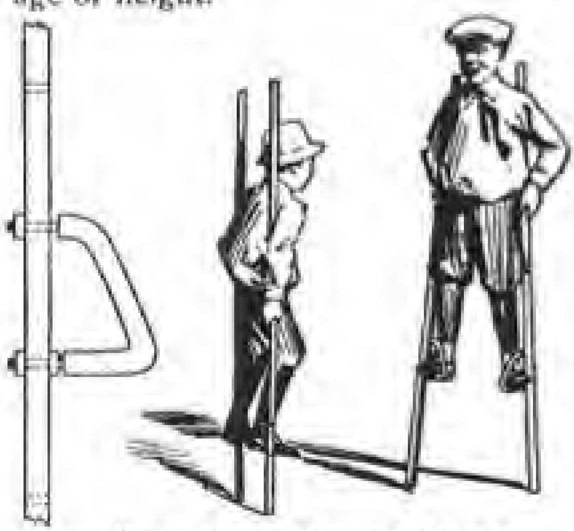
The Toy is Pushed by Means of the Handle, Causing the Horse to Walk

are attached to the legs, connecting with the offsets in the axle. □

Adjustable Stilts

Popular Mechanics — 1915

The beginner with stilts always selects short sticks so that he will not be very far from the ground, but as he becomes more experienced, the longer the sticks the better. Then, too, the small boy and the large boy require different lengths of sticks. The device shown makes a pair of sticks universal for use of beginners or a boy of any age or height.



Stilts Having Stirrups That can be Set at Any Desired Height

To make the stilts, procure two long hardwood sticks of even length, and smooth up the edges; then begin at a point 1 ft. from one end and bore 12 holes, ⅜ in. in diameter and 2 in. apart from center to center. If there is no diestock at hand, have a blacksmith, or mechanic, make a thread on both ends of a ⅜-in. rod, 12 in. long. Bend the rod in the shape shown, so that the two threaded ends will be just 2

Had just settled our brains for a long winter's nap;
When out on the lawn there arose such a clatter,
I sprang from the bed to see what was the matter.
Away to the window I flew like a flash,
Tore open the shutters and threw up the sash.
The moon on the breast of the new-fallen snow,
Gave the lustre of mid-day to objects below,
When, what to my wondering eyes should appear,
But a miniature sleigh, and eight tiny rein-deer,
With a little old driver, so lively and quick,
I knew in a moment it must be St. Nick.
More rapid than eagles his coursers they came,
And he whistled, and shouted, and called them by name;
"Now, *Dasher!* now, *Dancer!* now, *Prancer!* and *Vixen!*
On, *Comet!* on, *Cupid!* on, *Donder* and *Blitzen!*
To the top of the porch! to the top of the wall!
Now dash away! dash away! dash away all!"
As dry leaves that before the wild hurricane fly,
When they meet with an obstacle, mount to the sky;
So up to the house-top the coursers they flew,
With the sleigh full of toys, and St. Nicholas too.
And then, in a twinkling, I heard on the roof,
The prancing and pawing of each little hoof—

As I drew in my head, and was turning around,
Down the chimney St. Nicholas came with a bound.
He was dressed all in fur from his head to his foot,
And his clothes were all tarnished with ashes and soot;
A bundle of toys he had flung on his back,
And he looked like a peddler just opening his pack.
His eyes—how they twinkled! his dimples how merry!
His cheeks were like roses, his nose like a cherry!
His droll little mouth was drawn up like a bow,
And the beard of his chin was as white as the snow;
The stump of a pipe he held tight in his teeth,
And the smoke it encircled his head like a wreath;
He had a broad face and a little round belly,
That shook, when he laughed, like a bowlful of jelly.
He was chubby and plump, a right jolly old elf,
And I laughed when I saw him, in spite of myself;
A wink of his eye and a twist of his head,
Soon gave me to know I had nothing to dread;
He spoke not a word, but went straight to his work,
And filled all the stockings; then turned with a jerk,
And laying his finger aside of his nose,
And giving a nod, up the chimney he rose;
He sprang to his sleigh, to his team gave a whistle,
And away they all flew like the down of a thistle.
But I heard him exclaim, ere he drove out of sight,
"*Happy Christmas to all, and to all a good-night!*"

in. apart from center to center. The thread on the straight horizontal end should be so long that a nut can be placed on both sides of the stick. A piece of a garden hose or small rubber hose, slipped on the rod, will keep the shoe sole from slipping. The steps can be set in any two adjacent holes to give the desired height.

A Porch Swing

(FROM POPULAR MECHANICS 1919)

The seat of the swing consists of a board, 30 in. long, 14 in. wide, and 1 in. thick, with holes bored in each corner for the ropes. The rail at the top is made of four oak pieces, two of them 30 in. long, for the sides, and the other two 18 in. long, for the ends; all 3 in. wide and 7/8 in. thick. The ends of these pieces are finished rounding, and holes are bored in them for the supporting ropes. The supports for the rails consist of four pieces of 3/4-in. pipe, 15 in. long. The ropes are run through the holes in the ends of the rails, down through the pipes and through the holes in the seat board, where they are knotted.

A Porch Swing Having a Rail That Incloses the Person Sitting in It

A rope tied to a convenient post or screw hook makes a handy way to give motion by pulling. To get into the swing, raise one of the side rails on the rope.

A Wire-Walking Toy

Popular Mechanics 1919

A daring wire-walking performer who, unmindful of the fact that a misstep may mean destruction, keeps on

A Christmas Story

I was in Australia a few years ago and found that Christmas came in summer. It was still December 25th but Australia is on the bottom side of the Earth and seasons are just opposite to what they are in America. When it's winter here, it's summer down there. They celebrate Christmas there, too, but since it comes in summer there is no snow so they don't have the same kind of Christmas stories we have. In fact, it didn't seem to me to be like Christmas at all but Australians are pretty good at pretending and besides, Australian kids weren't going to be left out of the gift-getting business, snow or not.

I decided to write a Christmas story which would fit them and thought you might like to read it.

Australians speak English, but not like Americans, at least with a lot of words Americans haven't thought up. Also, a lot of them don't pronounce their H's. A long time ago many Australians were miners always digging for gold and opals and such and were called "diggers". The angels in the story are called diggers because of that.

SANTA'S KANGAROOS

by KURT SAXON

It was Christmas Eve in Australia and all the kiddies were waiting for Santa Clause.

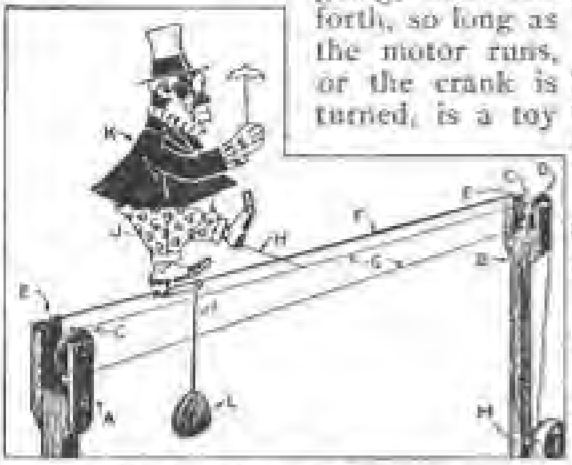
Some of them had been very good for a little while during the past year. They were looking over lists they had made with just about every toy you can imagine written down.

Those who had been naughty nearly all last year were waiting just as eagerly. They figured Santa was an old softy (and he usually is) and would only remember when they had been helpful. Like keeping out of Mum's way when she was picking up their toys or telling Daddy when they threw the kitty down the well so that he could rescue her before she drowned.

Yes, they were all waiting. And, to be sure, Santa *was* coming.

His sleigh was piled high with koala bears and boomerangs and cricket bats and prams with dollies in them and ever so many other things.

It was very dark that night so Santa had his red nosed reindeer to guide him. This deer was very good at this sort of thing and had brought him through the worst weather for years. But there was something up ahead



Adapted to Window Displays, This Amusing Toy Has an Advertising Value

going, back and forth, so long as the motor runs, or the crank is turned, is a toy that boys can make easily. The wire is stretched, not across Broadway, but between two 1 by 1-in. standards, held upright by guy cords, or fixed to a baseboard. They are fitted with forked tops, at A and B, and pulley wheels, C and D. A wire, F, is fastened to two of the prongs, at E, and a black thread, G, runs over the pulley wheels. A carriage, I, is formed from a 12-in. length of stiff wire, and weighted, at L, to balance upon the tight wire. The figure K is cut from stiff paper, and made to turn upon the carriage upright J, and braced with thread, at H. Thus the figure is always drawn forward, revolving on the support J at the end of each trip. Power to turn the thread is transmitted from a hand crank or motor, M, by means of the double pulley wheel at

Mechanical Toy Alligator of Wood

Popular Mechanics 1919

A toy alligator that opens its mouth and wags its tail as it is pulled along can be made of wood by a boy, with a jackknife. The various parts, as shown, are cut from soft wood, ½ in. thick. The method of fastening the parts is shown in the side sectional view. When the wheels turn, the cams A, set on the crank portions of the wheel axles, raise and lower the jaw and tail. The upper jaw is 1 in. wide at the widest part, and 3 in. long. The lower jaw is smaller, and the same length. The body is 6 in. long, and tapering in width from 1½ to ¾ in. The tail is 4¾ in. long, and ¾ in. wide. Holes are drilled in each piece near the edge, at joining points, through which wires are drawn, and clamped, as at B. The legs are shown in detail. They are attached to the body by drilling a 1/16-in. hole in each, and a hole through the body, through which the fastenings are passed. The lower end of the legs are fastened to the base.

that the guide deer didn't know about and so wasn't looking for.

It was an artificial satellite. That's one of those things the Americans and the Russians have been shooting up into the sky so they can hear it say "Beep, Beep, Beep." I'm not saying whose it was but they should have taken the nasty thing back down. At least, on Christmas Eve!

Well, you guessed it. The guide deer didn't see it and the sleigh ran right smack into it. Santa was knocked out of the sleigh and the toys were scattered all over the clouds and the sleigh's runners were all bent out of shape.

As if this weren't enough, the reindeer were frightened out of their wits. Now, as you know, reindeer are very nervous animals and get upset over the littlest things. Anyway, they all jumped out of their traces and went as fast as they could toward the North Pole.

Well, there was Santa, just sitting on a cloud wringing his hands. He was wondering what all the Australian kiddies would think when they didn't find any toys that morning.

And the satellite was hovering around his head and going "Beep, Beep, Beep?" Beep, Beep, Beep?" Santa grabbed it and sent it spinning in the opposite direction to what it had been going. "That should make whoever put it up there ask some pretty funny questions," he thought.

But there he still was. With the toys all out of their sacks and his sleigh runners all bent. Now, it's a scientific fact that a sleigh won't fly through the sky with its runners all bent. Anybody knows that.

While he was sitting there, a Digger angel named Frank appeared and sat down beside him on the cloud.

"You got troubles, Mate?" asked Frank.

"I sure do," said Santa. "Look at this mess. How'll I get them all together again? How'll I fix my sleigh? I think I'm going to be sick."

"Don't worry, Mate," said Frank. "I'll get 'elp and we'll fix you up straight-away."

Then Frank gave a whistle and three more Digger angels appeared on the cloud. They were all got up just like Frank with floppy hats with big, broad brims. But so you could tell they were angels they had on white gowns and big wings. Two of them had bushy red beards and the other one had great moustaches which hung down on both sides.

"Mates, this'ere's Santa Clause," said Frank. And to Santa he said "And these 'ere are the 'Arrigan brothers: 'Arry, 'Erbert and 'Umphry."

"Pleased, I'm sure," said Santa.

'Arry, 'Erbert and 'Umphry grabbed their hats by the tops, raised them a foot off their heads and let them drop back down.

"Now, Mates," said Frank, "we got to get the toys back into the sacks and straighten the sleigh runners. 'Arry and 'Erbert, you round up all the toys whilst I and 'Umphry works on the sleigh."

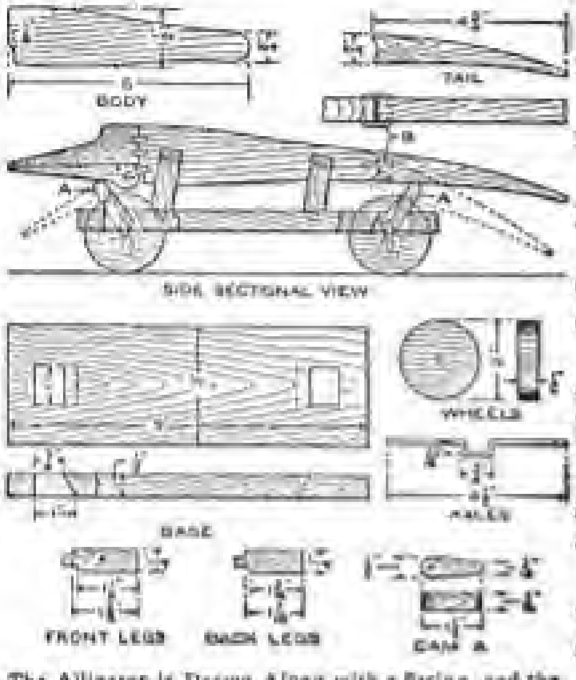
'Arry and 'Erbert straight-away bounded off and began picking up toys and cramming them into the toy sacks. While they were doing this, a Quantas jet liner came into view just below them. 'Arry immediately threw a boomerang at it. The boomerang looped down in front of the plane and barely missed cracking the pilot's windscreen. The jet liner seemed to go out of control, then, bucking up and down and swerving from side to side.

As soon as it got back on course 'Erbert appeared in its path pushing a pram with a dolly in it, like a woman crossing a street in traffic. Again the plane bucked up and down and swerved from side to side. Then it turned around and flew back to the Sydney Airport.

As soon as the plane landed the pilot was called to the office to explain his return. "Well, Sir," he said, "here I was, sixteen thousand feet up, mind you, and a boomerang whizzes past my windscreen. *Of course* it upset me. I lost control of the plane for a minute then straightened her out again.

"Then, just up ahead, I sees this bloke in a floppy hat and with wings on and he's pushin' a pram with a dolly in it. Sixteen thousand feet up in the air and nothing under him. And pushing a pram with a dolly in it. Of course I turned around and came back."

which is 3 by 9 in. long. Square holes, 1 in. wide, near each end, are provided for the cams A. The axles and wheels are made as shown. The axles fit



The Alligator is Drawn Along with a String, and the Jaws and Tail Flip Up and Down

tightly in the wheels, so that the latter can move the axles around with each turn. The axles are made from ⅛-in. wire, bent as shown, and should be long enough, after passing through the bottom, to extend through the wheels on each side.

He was going to tell the story all over again but some nice men took him to a place where he could rest.

In the meantime, 'Arry and 'Erbert had got the toys all back in their sacks. Frank and 'Umphry had straightened the sleigh runners and everybody was happy but Santa.

"Now you're all right, Mate," said Frank. "She's just as good as new and not a toy was lost."

"That's fine," said Santa, "but how can I go without a team? My reindeer are probably half way home by now."

Frank thought a moment and said, "Well, Mate, we'll just have to outfit you with kangaroos."

The 'Arrigan brothers seemed delighted with the idea and immediately disappeared. Santa didn't much think it would work but since Frank disappeared just a moment later he couldn't ask for explanations.

The four Digger angels scrounged the outback around Alice Springs and soon caught eight bouncing roos. They had to drag them back by force because the kangaroos didn't have any Christmas spirit at all.

But finally they got them to the sleigh and all hitched up. They even gave them names: Bunyip, Geelong, Pimba, Gympie, Roto, Quilpie, Joe and Sam.

As soon as they were ready Santa shouted, "Giddyap," and off they went, hopping through the sky as nice as you please. But it was a dark and stormy night and Santa sorely missed his red-nosed guide deer.

He had hardly gone any distance at all when 'Arry and 'Erbert appeared with another kangaroo. They called him Fair Dinkum and his nose was even redder than that of Santa's guide deer. They had got his nose like that by filling him up with good Aussie beer.

Then Santa started off again led by Fair Dinkum the red-nosed kangaroo. And soon the job was done and every city, town, village and bush camp in Australia had been visited.

When Santa got to Darwin and left the last of the toys he found his reindeer waiting for him. They had gotten over their fright and had gone back to look for him. But when they saw the sleigh pulled by those jolly kangaroos they figured they could take a rest during his Australian run.

When Santa got to them they welcomed him heartily and frisked about his sleigh. Soon the kangaroos were unhitched and replaced by the reindeer.

Then Frank, 'Arry, 'Erbert and 'Umphry waved goodby to Santa and disappeared with all the kangaroos. Santa yelled "Thank you and Merry Christmas" toward the spot where they had been standing.

Then he turned his reindeer north and headed home.

The End

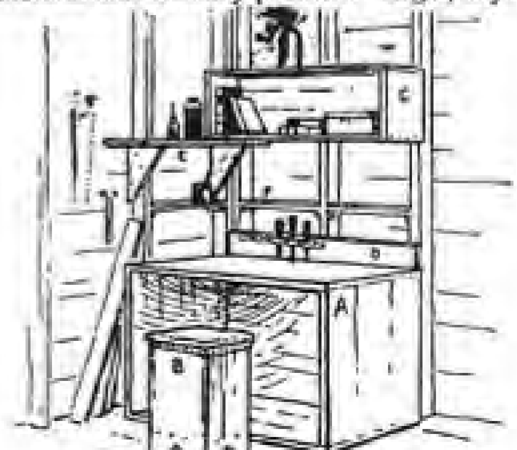
CHEAPLY AND EASILY MADE TOYS

Here is another selection of toys any parent can whip up for the little ones which will give them lots of playing time with less breakage and at practically no expense.

There are more such homemade toys in Volume one of THE SURVIVOR.

TOY-MAKING

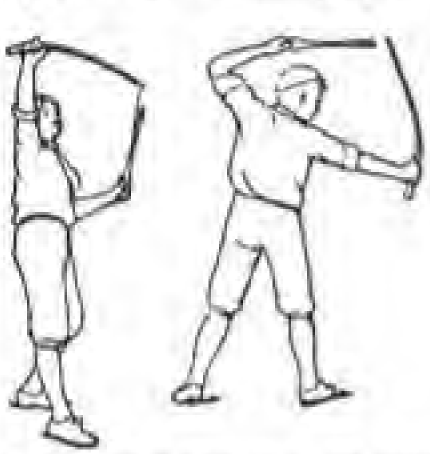
SOMEWHERE in your house there must be a corner where you may have a little workshop of your own. With some packing boxes of different sizes, such as you can buy at a grocery or dry-goods store, you can make a bench, a stool, and a shelf or two, like those shown in this sketch, and so make a beginning. For tools you will need a saw, a hammer, a try-square, a good jackknife, a plane, a ruler, and compasses. A pair of stout scissors will do for cutting paper, cardboard, leather, tin, and so on; and a pair of cutting pliers will be useful for cutting wire. Perhaps you cannot get all these tools at once. Never mind; begin with a jackknife, a saw, and a hammer, and add other tools as fast as you can pick them up. As soon as your family know of your enterprise, they will be likely to remember it in making Christmas and birthday presents. Begin, any-

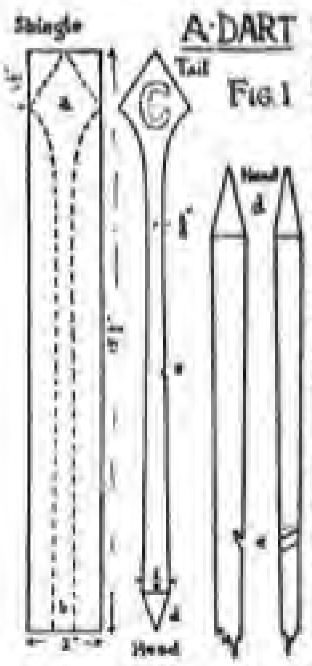


how. Your shop will grow, and your love of it will grow. There is no satisfaction quite like that which comes from making things with your own hands.

A DART is a good thing to begin with. Find a piece of straight-grained shingle two inches wide, and cut it as shown in Fig. 1. After you have sharpened the head end, balance the dart on the edge of your knife-blade and at the balancing point cut the notch. For a whip handle you will need a springy stick such as you can easily cut from a roadside thicket. Cut it two and a half feet long, and a little less than an inch through at the butt end. A stout string or thong a foot long knotted at one end and tied to the stick at the other will complete the whip-bow. Holding bow and dart as in the picture, sling the dart with a motion such as you would make if you were to whip a fiend and had but one chance.

In the making of even this simple dart you will have learned two things at least. One is that it pays to save and store away in your work-



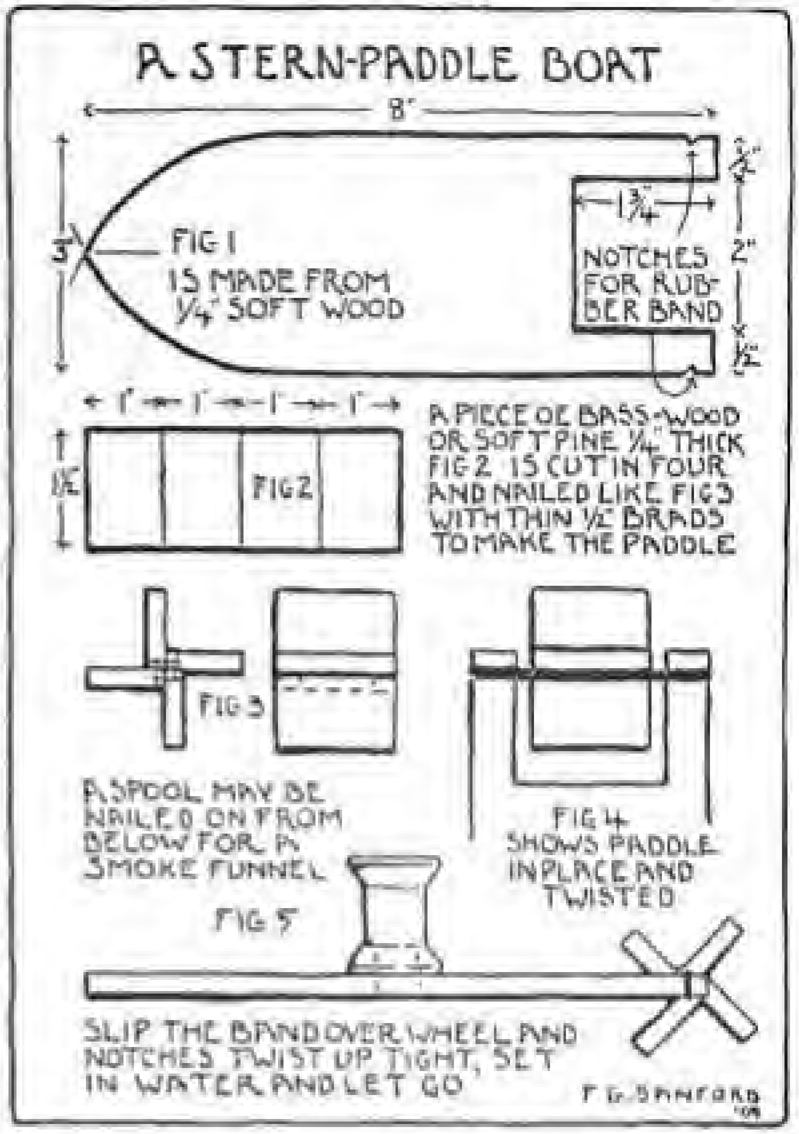


shop odd pieces of wood, string, rawhide, shoe-leather and such like. Part of the fun of a workshop is the chance it gives you to gather materials that will come in handy at one time or another. The other — a very different sort of thing — is that wood splits along the grain. Of course you knew that to start with; but no matter how skillful and experienced a woodworker you may become, you will always have to take account of the grain of your wood, whether whittling, or planing, or carving, or sandpapering. Working with the grain is like smoothing a cat's fur the right way, — all is serene and as it should be; working against the grain, — well, you know how the cat likes it!

The plan given on this page is for a PADDLE-WHEELER of the stern-wheel type. You know that on shallow rivers and on rivers in which there are sand bars to go over, like the Mississippi and the Ohio, stern-wheelers are much in use. They go pretty well in bath-tubs, too. By consulting the plan you will see that the hull should be fashioned from a ¼ inch slab of soft wood, the outline being patterned on a piece of 3 by 8 inch paper folded lengthwise to make both bow curves just alike, marked on the wood and cut out with the scroll saw.

Remember in cutting out the square inside corners of the paddle opening not to force the saw but to keep it working up and down while you turn the wood slowly. And then when you come to the second inside corner you will have to back out and make the last cut from the outside, unless you have a scroll saw large enough to allow the length of the boat to pass between its shanks.

The construction of the rest of the boat is made clear in the diagram. A tack-hammer will be found useful in nailing the parts of the paddle-wheel together. If one of these parts splits, keep patient and try another.

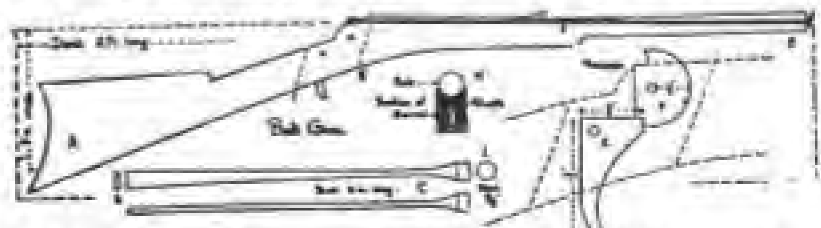


You can add realism to the short voyage by sticking a small Christmas candle into the hole of the spool and lighting it.

Here are drawings that show you how to make a BOLT GUN, with which much fun may be had during long indoor winter evenings. A description of the making is on the next page.

To make the gun, get two pieces of very thin pine or whitewood board, ⅛ inch thick, 2 feet long and 5 inches wide, and another board of the same length and width, but ¼ inch thick. On one of the thin boards draw the outline of the gun. When this has been whittled or scroll-sawed out, use it as a pattern and cut the other boards accordingly. Tack the three together, the thinnest one in the middle, with three small brads; and smooth the three parts into one gun-stock.

Whittle or saw out D and E, the trigger pieces. Then pry off one side of the gun; and, laying the trigger in position, mark lines *f* and *g*, and cut out of the middle piece a piece along these lines. Then pry off part F of the middle piece, and remove ⅛ inch from its upper edge. Bevel the edges of the thin pieces

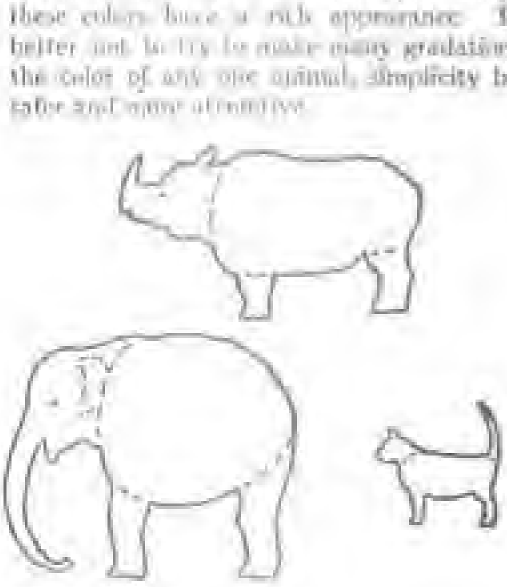


so that when the parts are brought together again, the barrel will look like the section drawn at H, end view. Then put all the parts together, running brads through the two trigger parts in such a way as to pivot them properly. You will see the wisdom of marking the points at which these pivot brads are to enter, before you finally fasten the stock parts together.

By means of a staple, fasten to the end of the barrel a good spunky rubber band, 3 inches long and ¼ inch wide. With this you can throw bolts of wood as straight as a rifle-ball across the room at a target of paper pinned upon a rug thrown over a chair; and moderate care in the aiming will do away with any risk of damage to the vases on the mantel.

There is a wide field to range when it comes to selecting and making the animals that are to be the inhabitants of our ark. Here on this page are given designs for what will be surely a sufficient number to start with. The outlines are extremely lifelike, and the effect is especially real when the figures are made up of three thicknesses so that they will stand.

First of all make your patterns. If you decide to make the animals of just the size shown on this page, trace off the outlines on very thin paper, and transfer them to the wood by using carbon paper. Get some pieces of very thin wood, and select those pieces that will match up pretty well in size for one of the figures. You may have to saw them a little. Wood such as the school chalk boxes offer, is a handy gauge for this work. Nail these pieces lightly together with small brads, and lay off the pattern on the top piece. Then cut out all three together. The pieces are then to be taken apart, and certain of them changed. In the case of the elephant, for example, the two outer thicknesses of the head part should be cut away, along the line indicated in the diagram, while the middle piece should have the head left on, but the legs cut off. In each case, you see, the center piece is to bear the head, and the outside pieces are to carry the legs. Where there is a tail, that also is to be on the center piece. When the parts are cut out according to this scheme, they should be glued together, and when they are set, the sharp edges may be rounded off and as much carving done as you care to try. Finally comes the coloring. This should be done with oil colors, preferably, as these colors have a rich appearance. It is better not to try to make many gradations in the color of any one animal, simplicity being safer and more attractive.



The NOAH'S ARK is not so hard to make as might be imagined, and it is a most delightful toy. Begin with the bottom of the house, two by five inches, and build around that. You will need two duplicate gable ends and two sides and two roof pieces, almost everything being two by two in this ark as should be the case in every well-regulated ark. You will notice that one roof piece is nailed in place, while the other is left removable, and is caused to stay in place by means of an extra piece glued to its under side (see dotted lines in end view). The boat is sawed and shaped from a ⅞" board. The parts should all be put together with brads. Once together, the ark should be painted in bright colors. The deck, as you will see in the illustration, may be lined out with different colors; and there should be a painted window at each end, or how could the dove get out? It would be a pity not to have Noah and his family, as well as the animals which are to be explained on the next page, and do you think you could whittle them out? It is not difficult. Short pine sticks are easily carved.

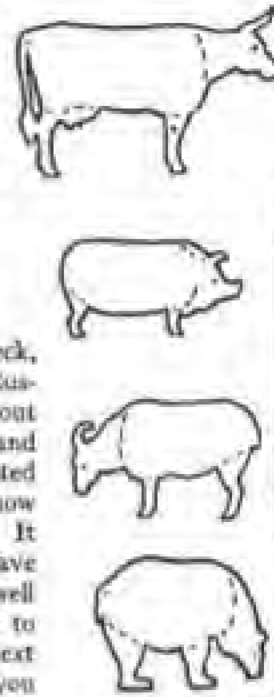
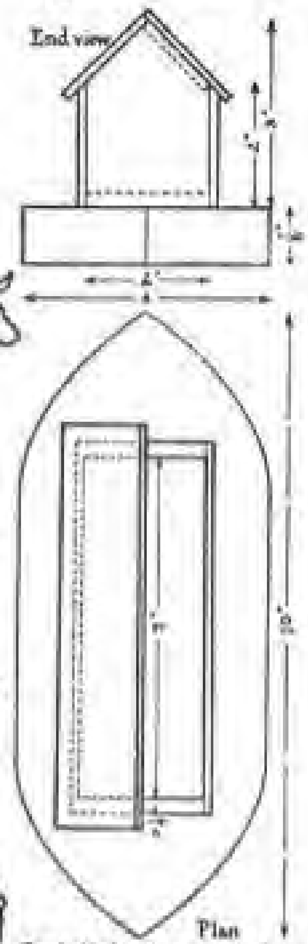
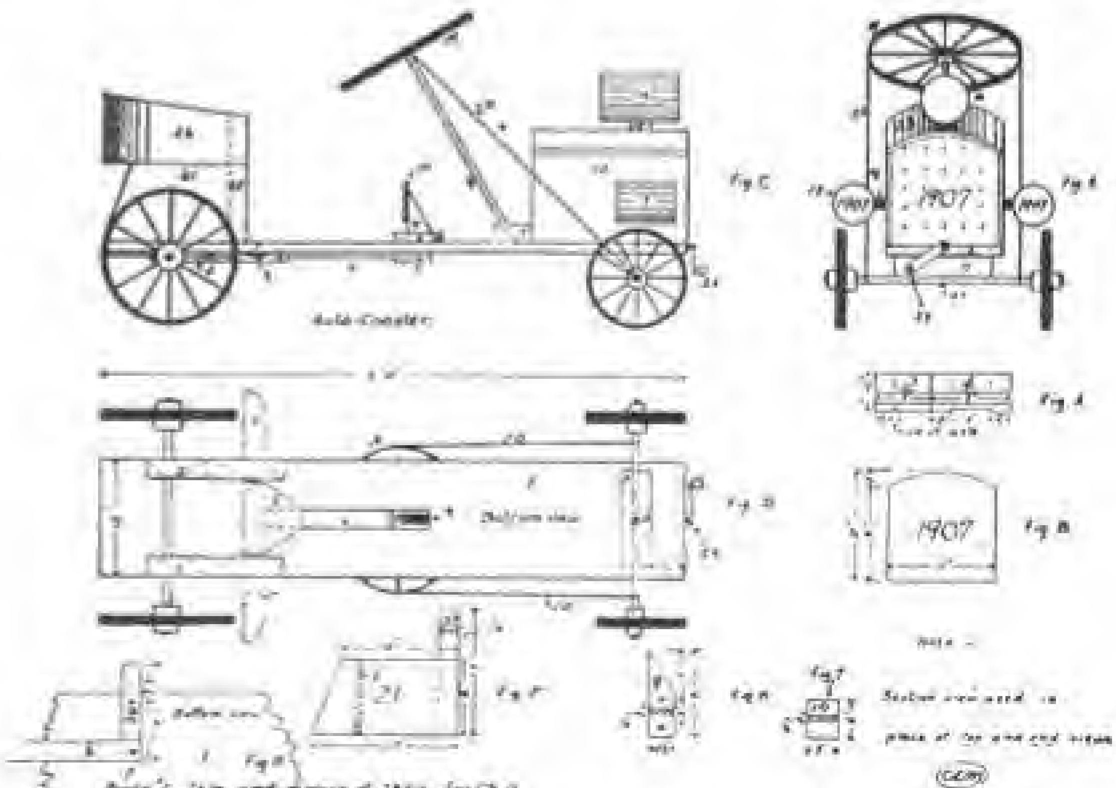


Fig. 9. Noah's Ark



One-half of roof removed to show the interior.



Here is an AUTO-COASTER that will give you almost as much fun in summer as a bob-sled or double-runner will in winter.

The first thing to do is to find a pair of stout wheels. These are to be fitted to the 12" × 5' bottom board of one-inch planking. The board must be raised sufficiently from the front axle, by means of a "riser" block, to be level, the front axle being lower than the rear. This "riser" carries the king-bolt or pivot of the front pair. To the under side of the bottom board and four inches from the end screw two strips 1" × 2" × 6", with a groove cut to receive the axle. Extending beyond these strips fasten two brake-straps, 1" × 2" × 8", each provided with a groove ½" by 2" by 4" to admit the brakes (see 4 in Figs. A and D). Two and 4 in the Figs. A and D may be made in one piece; but remember that the measurements here given are for 14" wheels, so that a change in the length of the strap and the location of the groove would have to be made if your wheels were of a different size. lamps are to be bolted in place in a similar way. Use cans with slip tops that may be replaced after the bolting has been done. Measurements for the seat can be taken from the diagram. The rounding top is made of a cheese box with the front cut and straightened out, and the sides tapered. Two sorts of brakes are possible, but the foot-brake is to be preferred. Paint the car red, and don't forget the tail-number. If you wish, you can fix your dark-lantern within the search-light can.

When "off," the brake should rest one inch from the wheels.

The hood is made of a box 12" × 12" × 20". The boards are to be removed carefully and replaced when the box-ends have been shaped as seen in Fig. B. Before putting the last board on again reach in and bolt the search-light on. The search-light is a 2 qt. can. Through it and through the pivot block (1" × 2" × 2") and the top board of the hood bore a hole for the bolt, which should be set just tight enough to allow the light to turn. The side

THE SURVIVOR

Volume 2 By Kurt Saxon

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No-soil garden

Chicago Tribune, Sunday, July 3, 1977

By Joseph Egelhof

SYRACUSE, N. Y.—The navy cooks at Argentia, Nfld., are getting a year-round salad garden.

It will be in three trailers, each 12 by 42 feet. One will grow tomatoes, one lettuce, and one cucumbers.

From that growing area the cooks will pick enough vegetables to make 400 high-quality salads every day, forever.

All that from 36 by 42 feet of garden? How?

It will be a "total control" growing system, developed here by General Electric Co.

Destined for use one day in space habitats, GE's new concentrated gardening may revolutionize vegetable production.

The Pentagon has just signed a contract for a movable system for the U.S. communications base at Argentia. It could be parked anywhere, from the Arctic to the deserts, and still function.

THE GE ENGINEERS and horticulturalists here say they have seen amazing improvements in the production of vegetables.

Compared with greenhouse crops, they are getting 20 times as much lettuce, nine times as much tomatoes, and six times as much cucumbers, measured in pounds per square foot of growing area.

The comparison with field-grown crops is even more spectacular. Forty times greater for lettuce, 30 times greater for tomatoes, 50 times greater for cucumbers.

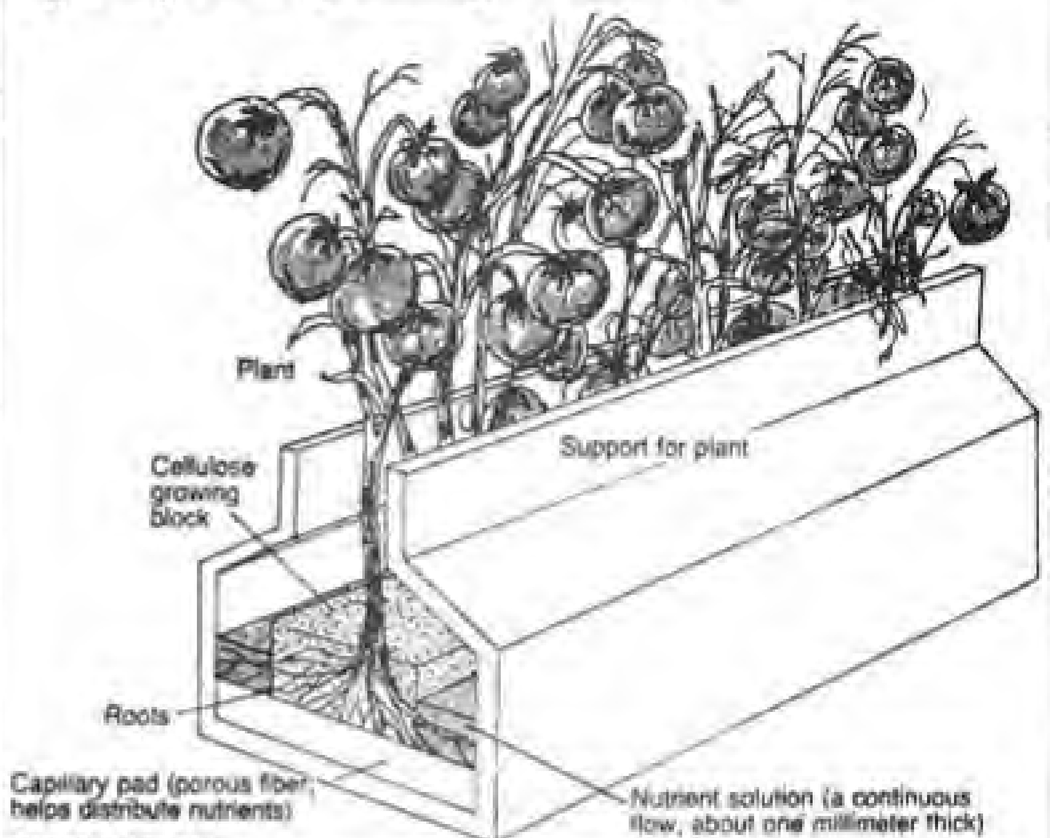
The plants are grown in open-topped troughs without soil. A thin film of recirculated nutrient fluid trickles through their roots from one end of the trough to another. The troughs are mounted on Christmas-tree type racks so the vertical as well as the horizontal dimension is filled, to take advantage of all of the carbon-dioxide enriched atmosphere. The racks are movable, so space for only one aisle is needed. The "sun" is a combination of high-intensity electric lamps. The temperature and humidity are controlled. You enter through airlocks.

THE ARGENTIA system will have a fourth trailer to house the nutrient tanks and pumps and other machinery.

Happy with their success, the GE engineers envision modules in other sizes. A refrigerator size, to hold ornamental plants for offices or possibly a year-round small garden for homes.

Commercial systems might be in the five-acre size, said Engineer Lewis W. Fogg. He is manager of the controlled-environment agriculture task force set up four years ago by Thomas I. Paganelli, vice president who heads GE's electronic systems.

Hydroponic growing technique



Source: General Electric Co.

A five-acre tomato system would produce 8 million pounds of tomatoes the first year. Output would rise gradually to 11 million pounds a year.

Fogg envisions three such five-acre plants spotted around Chicago to take care of the metropolitan area's entire need for "premium-grade" tomatoes.

THE GE CROPS are of uniform high quality and the system can be adjusted to produce varying tastes.

GE grows lettuce to standard sized heads of three-quarter pounds in 21 days from the time the seedling is transplanted. But it added another six days and produced a head weighing 2.2 pounds and 20 inches in diameter. Too big for the home refrigerator but ideal for the restaurant market, Fogg thinks.

The engineers keep the quality high when growing giant lettuce and cucumbers. They think four-pound cucumbers that don't have to be peeled could be marketed wrapped in pieces.

Fogg said his group is using "physiological manipulation" on the plants.

"WE EXPOSE the tomato plants when they are seedlings to cold shock, 10 days in a much lower temperature than normal," he explained. "The plant 'thinks' it is going to die, so its life processes speed up. When we put it in the warm module, it is well ahead of normal. It throws its first cluster about six inches from the root and becomes a very short, thick-stemmed plant with three clusters at six-inch intervals."

The short plant is suitable for the rack-type growing structure.

GE is going into ornamental plants to supply a company in the "plant party" business.

"That's a geranium we grew from seed in 6 weeks," Fogg said. "The greenhouse operator normally takes six months."

Pharmaceutical companies have asked GE to grow the digitalis plant to eliminate silica impurities and get a uniform, hopefully higher percentage of the vital alkaloid.

"WE HAVE GREAT confidence we can increase the alkaloid by use of nutrient factors and growth regulating," Fogg said.

Although economical on water, the process is electricity-intensive, with 30 per cent of the cost going for power. But Fogg said in total energy of all kinds consumed per pound of product, "We are very competitive with the California farmer."

Some people can't believe GE is producing live tomatoes.

When a Syracuse supermarket operator offered some to market-test the quality, saying GE had produced them in its plant, one customer reported back that they were "better than real tomatoes."

The TANKS ARE COMING

(Practical Hydroponics)

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EARLE AUGUSTUS SPESSARD

An interesting, if illegal, example of indoor growing is the detailed article on page 23 of THE NEW IMPROVED POOR MAN'S JAMES BOND, "Marijuana Grower Shakes DEA". The grower spent about $75.00 per unit on two 4 1/2 x 2 1/2 foot units he built largely from easily available scrap. His plants matched a normal six month's growth in only nine weeks from seed. His lighting was by regular fluorescent shop lights and used only about $5.00 per month in electricity.

This same method can be used to grow tomatoes or other plants.

PREFACE

The present world-wide interest in hydroponics, judging from the many letters which have come to the writer's desk, stems from the age-old desire to have at hand an abundant supply of fresh, tasty food. The world is still hungry. And in those places where it is either dangerous or impossible to grow vegetables, many have come to look to hydroponics as a possible relief from the difficulties.

ILLUSTRATION 1. Corner of the feeding-tank, showing the nutrient-solution flowing into the feeding-channel by way of the faucet. A branch of one tomato plant showing a half-mature tomato can be seen growing next to the wall of the feeding-tank. Photograph by Mr. Ray Bruce.

But, in spite of this interest, there is little of practical value in the excellent bulletins and books on the subject which the average individual can use to advantage. The first objective of this volume is therefore to translate some of this valuable information into a language understandable to anyone with intelligence enough to raise a good garden.

The present systems of hydroponics were designed and developed in the interests of fundamental research. It was never expected that they could be used by people in general. A recent visit with most of the important investigators confirms this opinion. These systems are about as perfect in performance as could be reasonably desired, and are to be highly recommended for use in greenhouse establishments, and by anyone having the scientific and technical skill required to operate them. But for the man with limited time, training and money, it is generally agreed that they cannot be made practical.

Considering the above named conditions, the writer began, several years ago, the development of a hydroponic system which would do away with most of the mechanical and technical features, yet allow the evident advantages of the other systems. The second objective is, therefore, to explain in detail how to construct and operate this simplified form of hydroponicum.

I have not attempted to make things easy, or to oversimplify. I have deliberately tried to make certain sections interesting reading. The book can have little interest for those who wish to make a plaything of hydroponics, or to grow plants for amusement. It is intended for those who wish to eat better through their own efforts. The language is not for the plant-physiologist, or the technically trained.

It is for the gardener, whether he be a professional or one who enjoys his little back yard.

There is another group for whom the book is written, namely, those individuals who wish to make a living growing vegetables and flowers for the home market. This group consists of people who intend to do their own work and market their own product through local dealers. In fact, the system to be described was developed in precisely this way. It is expected that in a generation or so, through this system, every village, town and city will be supplied with the major portion of its perishable food supply.

The third objective of this book is, therefore, to lay out the general pattern for future hydroponic development in the world, and to induce serious-minded people, everywhere, to begin laying, in this generation, the foundations for this development.

This book is an enlargement of a mimeographed edition published and distributed by request in 1947, under the title *How to Construct and Operate a Spessard-Hydroponicum*, in the form of five "Lessons." Through these lessons, this simplified form of hydroponics is now in operation in every major country of the world, by one or more individuals. Some of these have consented to make reports on their success or failure, and to give weather conditions. Photographs on pages 49, 135, 143, 155, indicate the success of "students" with the use of the type of hydroponicum to be described. It is hoped that through this means, among those of us interested in having hydroponics become generally useful throughout the world, an interchange of valuable information will be possible. Indeed this is necessary, since up to the moment no Departments or Ministries of Agriculture have taken practical steps to satisfy the present desire for information.

ILLUSTRATION 2. A crop of pole Lima beans growing in a unit from which a crop of tomatoes was harvested earlier in the season. The figure in the background indicates the height of the vines. Photograph by Dr. Charles Deesers.

An explanation might be given here for not emphasizing what is commonly known as "deficiency" troubles. The obvious answer is that if we propose to give a plant what it needs, there won't be any deficiencies. Thus, why worry the beginner with such matters? But there is another reason. The information published is often contradictory, and thus confusing; or, it was derived from observations made on greenhouse material. These conditions do not necessarily hold in outdoor growing, in regions where weather changes are often violent.

E. A. Spessard
Conway, Arkansas
U. S. A.

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CHAPTER I

Hydroponic Systems Now in Use

I. THE BACKGROUND

A. PUBLIC REACTIONS TO NEW IDEAS. When the public first learns that a new and practical device has appeared ready for use, it receives the news with eager excitement, and waits to see who will first be fool enough to try it out. During this initial period the "sucker-baiters" have their little day, and the stupid victims come, in time, to wonder once more why they were so easily "taken in." But a few will work quietly at testing the new device, with the idea of bringing it into general use; perhaps, of improving it. So has it been with hydroponics since its introduction to the public by Ellis and Swaney, 1938; Turner and Henry, 1939; Gericke, 1940, and Laurie, 1940, through their separate books on the subject. In those references the reader will find the names of some of the many people who have, in one way or another, contributed to the development of hydroponics, as well as the principal universities and experiment stations in the United States and Canada, where the significant work in hydroponics was initiated and carried to completion.

What the public does not know is that for at least a decade before any of these books were published, growing plants hydroponically for commercial use had been going on in a few places. Also, it rarely learns that back of all hydroponics are two centuries and a half of rigid scientific experimentation in the plant laboratories of the world. Let us then set down the principal steps which were taken in bringing hydroponics to its present state.

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B. FIRST STEPS. Finding out who did what, first, is much like trying to find a needle in a haystack. Someone suggested recently, in a magazine article, that the Chinese gentleman who first discovered by accident that beans would sprout in a wet sack, started hydroponics. Unfortunately, the man ate the sprouts, thus failing to prove that the beans would reach maturity in the bag habitat. He contributed much to the bean-sprout industry and chop suey, but precisely nothing to hydroponics. No doubt Leonardo da Vinci had a hand in it, but there is no record of it, to the writer's knowledge. The first real steps in hydroponics were taken by scientists called plant physiologists. These are the things they did:

1. Showed that plants are as alive as animals.
2. Proved that water is absorbed by the roots, passes through the plant, and escapes into the air through pores in the leaves.
3. Proved that plants use oxygen in respiration, as do animals.
4. Showed that plants take up chemical salts in solution from either soil or water by means of their roots, carbon dioxide from the air by their leaves, and oxygen by means of their roots.
5. Determined what kinds of elements found in the various chemical salts are actually used by the plant to make its body and do its work. These they named "The Essential Elements."
6. Found out how to balance these elements when fed to plants in nutrient solutions of water and chemical salts.
7. Established the proper acidity of the nutrient solution.
8. Worked out formulas for making up nutrient solutions.
9. Demonstrated that plants could be grown to maturity in the nutrient solution alone, or in sand, gravel or other material flushed with the nutrient solution.[3]

Let me repeat for emphasis, it took these scientific men and women 250 years at least to establish these few simple facts about plants. Why so long? Plant physiology is in many respects a much more difficult science than the others. Plants have no nervous mechanism for revealing their needs and their troubles. They have no circulatory system from which plant "blood" might be tested quickly for a diagnosis. Their sap is in no way comparable to blood. The plants we ordinarily eat have so short a life span that any study we make of one individual is necessarily incomplete. To argue the point is not our purpose. It is desired only to point out that to learn a few simple things about how plants live is a most difficult task. The nine items given above are not the only ones, of course, which have been worked out in plant physiology, but they are the ones which had to be done before hydroponics was possible.

The second step was also done in the laboratory. To get oxygen to the roots; to keep the water-stream going through the plants, regardless of the amounts of elements the plants might use; to keep the acidity of the solution favorable to the plants; to keep high temperatures from ruining the roots—all these problems had to be met through devising proper mechanical systems for handling a large number of plants at one time, and equally. Otherwise no proper conclusions could be drawn. Plants have to be grown in numbers, and under as like conditions as possible, for correct results. Out of all this work came the use of such things as sand, gravel and other substances into which the plants might be set, and through which the nutrient solution might be run and aerated. The second step, consisting of the mechanical details for doing all this, was, therefore, also developed in the laboratory.

The third step was to apply the findings of the laboratories to commercial growing. In 1921, Pember and Adams,[4] at the Rhode Island Experimental Station, began applying nutrient solutions to growing carnations in sand. By 1929 Gericke in California had demonstrated the practicability of growing vegetables and flowers hydroponically, and received nation-wide recognition for his work. Two others, Biekart and Conners, at the New Jersey Experimental Station, grew flowers successfully on a commercial basis during the next ten years.

In a way, these were all epochal events. For they demonstrated that plants could be grown commercially by methods used in the laboratory. The next question was, could this be done economically? Gericke, as well as Turner and Henry, proved that it could.

C. Hydroponics remained for a long time in the hands of experts. Only well-established greenhouse firms with enough capital to maintain the expensive equipment, as well as skilled personnel, could hope to operate the systems developed in the laboratory. It should be emphasized that in a laboratory, expense is not the first consideration. There, it is the scientific result which comes first. But in growing things commercially, expense is of first importance, both in construction and in operation. The next significant step would be, therefore, that of bringing hydroponics into general use by reducing its present complexities.

If we go on the principle that after a certain point is reached, precision becomes a luxury, it becomes a practical necessity to eliminate in hydroponics all machinery which does not pay its way. The problem then resolves itself into one of doing away with the non-essentials without destroying the advantages obtained by hydroponics. It was this problem which the writer assigned himself some years ago. The technique developed, and the system adopted as a consequence of this study, are here reported for the first time. It is hoped[5] that in this system we now have a practical method for growing plants hydroponically, the world over.

II. The Hydroponic Problems

These may be grouped conveniently under two general headings. The first are those fixed by the nature of the plant's way of life. The second are those of the operator, and arise because he is trying to induce the plant to do its work under a set of conditions not entirely natural to it.

Of the odd million kinds of plants growing on this earth, only a few hundred are cultivated for use. Left to themselves, they rarely grow in sufficient abundance at any one place to provide a dependable food supply for man. But man has been cultivating the choicest ones for so long, both by agricultural and breeding methods, that they respond fairly well to intelligent care. Since hydroponics is supposed to be the most intelligent way, so far devised, for growing plants, the one who attempts to master the technique of this method should first acquaint himself with the plant's problems, like any good gardener would. For, unless he first understands what the plant is trying to do, he is more than likely to get in its way. In such cases, the plant invariably gives up whatever ghost a plant may have.

A. THE PLANT'S PROBLEMS. In general, these are the same as yours; namely, to grow up, protect itself against its enemies, and to leave offspring. It has no way of enjoying itself, or of being concerned about its own welfare. What it does is done automatically, precisely as you do, with respect to purely bodily processes. If you do certain things a plant never does, so a plant does at least one thing you never do. Before a plant can grow, it must make its own food. You appropriate food either from animals or from plants. But a plant cannot do this. This fact fixes certain problems which one who grows plants must recognize. Let us now list the

plant's specific problems which we may help it solve hydroponically:

1. A living green plant does work. This requires that energy be available to be used up or transformed.
2. The only source of energy available is sunlight.
3. To capture the sunlight the plant has to "pickle" it inside a chemical particle, called sugar.
4. To be able to lock up sunlight requires that the plant first have water, carbon dioxide gas, a suitable temperature, and the green-colored substance, called chlorophyll. Any plant that does not have this material cannot lock up sunlight.
5. It frees this locked-up energy by bringing in oxygen for burning the elements, carbon and hydrogen, in the sugar particle, thus turning these back again into carbon dioxide and water. The energy, thus liberated, is heat.
6. This heat is then used by the plant in various ways.
7. To furnish the oxygen for burning, the roots must be able to absorb it, precisely as your lungs take it in during respiration. This is a very important thing to remember in hydroponics.
8. To build its body, the plant must also absorb mineral and nitrogen-bearing chemical salts in solution, through its roots.
9. To distribute these to the parts needed an extra supply of water must be absorbed through the roots, and in sufficient quantity to provide an unbroken water-mass from roots to leaves.
10. The plant's food is the same as yours, namely, sugar or carbohydrate, fats, proteins, minerals and vitamins. But before it can "eat" it must first take in the things named above, and from them manufacture its "food." Thus,

strictly speaking, we do not actually feed plants. They feed themselves from the food they manufacture. Our problem is merely to make it possible for them to do this.

This distinction is not merely an academic one. It has practical significance. A considerable amount of literature is going the rounds, charging that plants "naturally" do not require "minerals." It is stated that plants grown on land enriched with "mineral fertilizers, produce puffy and tasteless fruits." Such statements are entirely misleading. The fact is that very little "organic" matter is absorbed and used directly by green plants, and tastelessness has been shown to be due, in some instances at least, to a lack of certain elements rather than to their presence, as alleged. If minerals are categorically "harmful" to plants and humans alike, then the human race has been making an awful mistake in its eating habits for the past million years.

In hydroponics we use minerals exclusively, with the normal supply of nitrogen included. The so-called special benefits of "organic farming," which the average objectors worry about so inconsistently, are provided happily in carbon dioxide, water, and nitrates in a hydroponicum. Plants seem to be unable to prejudice themselves against the carbon, hydrogen and nitrogen found in these substances. They hold the same attraction for hydroponically-grown plants as if they had been born and bred in a manure or compost heap.

B. THE OPERATOR'S PROBLEMS. These are, of course, to provide temperature, light, water, oxygen, carbon dioxide, and minerals, together with nitrogen-containing salts, to the plant as it needs them. These are precisely the problems, in general, of any good gardener. The problems peculiar to hydroponics are:

1. Keeping the roots constantly supplied with oxygen.

2. Keeping the roots constantly supplied with water and chemicals in solution.
3. Keeping the concentration and acidity of the nutrient favorable for plant growth.

The problem of what to feed plants in a hydroponicum is like that of any other type of gardening. Plants use the same kind of materials for food making, whether grown in an ordinary garden, the field, or a hydroponicum.

Hydroponic "farming" differs from other kinds of farming only in the mechanics of operation. Instead of plowing or spading, you flood the tank with water or sterilizing solution and stir the sand. Instead of cultivating with a tractor and shovel, you may use a frog-gig for light stirring; and if you are really good at the thing, you omit the frog-gig. Instead of hauling and spreading manure or other "fertilizer" you dump a pound of clean salts into a barrel, let it sit a while, test for acidity, open a faucet or pull a wooden plug, and let the sand soak the solution up.

Since the problems of hydroponics are essentially the same as those in ordinary gardening or farming, it is strange to find that so many are frightened at the idea of attempting it. After all, is there so much difference between the expression 4-12-4 on a bag of "fertilizer" and the expression KNO_3? If one has to learn a few simple things in hydroponics to be successful, does he not also have to learn more things to garden successfully? Give the same intelligent care to a hydroponicum that you do to a good garden; get accustomed to opening a faucet instead of dragging a plow; get into the habit of saying "essential element" instead of "fertilizer," and the imaginary difficulties of hydroponics disappear. Actually, the number of people who try to raise a garden and fail each year is enormous. Yet these same dupes will persist through

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half a lifetime of semi-failure without once trying to eliminate failure by learning hydroponics.

Another problem must be mentioned at this point. There is an impression that insect and fungus diseases are eliminated in hydroponics. This is not the case. However, such pests are much more easily controlled in a hydroponicum, and at lower cost in labor and materials. If heavy spraying is necessary, the excess may be washed from the roots quickly, thus avoiding poisoning from this source. All in all, the crop-care, required in ordinary gardening, remains in a hydroponicum. But (and this is most important), the heavy labor and expense of plowing and cultivating are eliminated. The problems of too much or too little rain are, of course, practically eliminated.

The most acute problem in hydroponics is that of securing food-grade chemicals at a reasonable cost. Earlier writers painted a rather rosy picture. They speak of buying chemicals in carload lots. Now anyone is perfectly aware that only very large operators could possibly afford to buy in this manner. The "little fellow" has either to buy at "drug-store" prices or use a combination of better grade "fertilizers." In the first case, the cost is too high, and in the second, his formula becomes rather cumbersome. This in turn makes it impossible to be as precise in feeding as desirable for best results. "Fertilizer," "chemical,' and "essential elements" are not identical terms, as the reader must learn. See Chapters 3, 5, and 7.

It is hoped that by the time this book is ready for press, positive steps will have been taken to improve the present facilities for distributing food-grade chemicals to operators of hydroponica.

The reader should be informed, however, that "fertilizer" companies and "chemical" companies operate under

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different legal requirements. He should, therefore, not throw blame on either one if he finds them hesitant to supply his particular request. The fact is, up until now, hydroponics has been either in possession of a few experts, large-scale operators, or the armed forces. Chemicals are available to these groups. The "fertilizer" companies, on the other hand, have had their hands full, trying to make up stuff that could be applied to soil-growing exclusively, and be distributed legally. There simply has been no comparable demand, so far, for food-grade chemicals, because there are too few hydroponica in operation. Therefore, those who should and will be interested in this trade have not yet appreciated the problem. They will in time, as hydroponics grow, you may be sure. There are a few distributors who buy up food materials for growing pet household plants. But they sell them at prices too high to be considered in hydroponica except those used as hobbies, and where costs are not a consideration. In short, the small operator of a hydroponicum has been left out in the cold, with respect to buying his chemicals easily and reasonably.

Another problem, and an important one in tropical and sub-tropical areas, is that of keeping mosquito larva, dysentery amoeba and typhoid bacteria out of the tanks. This is the same problem encountered in soil gardening. But in operating a hydroponicum these organisms are easily controlled, thus making fresh vegetables available anywhere on earth, provided the proper type of hydroponicum is selected.

Let us now consider the various systems which have been devised to meet the plant's problems by hydroponic techniques.

III. The Hydroponic Systems

For practical purposes, we may group the various hydroponica types on the basis of the mechanical arrangement for

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getting the plant supplied with chemical salts, air and water. All of them, to be considered successful, must stand up under violent changes of temperature, light, wind movements and rainfall. The one that does this best is the one to use, provided it can be built and operated economically.

There are three basic systems, which may be conveniently named: (A) The Gericke System; (B) The "Aggregate" System; (C) The Spessard System. They have in common a tank, or "basin," in which the plants to be grown, are placed. This is filled either with nutrient solution alone, or some "aggregate" such as sand, gravel, cinders, clay pellets, or even rock wool, over which the nutrient solution is passed from a storage or mixing tank.

A. THE GERICKE SYSTEM. The essential features of this system are:

1. A tank for holding the nutrient solution. This may be reinforced concrete, wood or metal. It must be waterproof and level.

2. A "litter or seed bed," made to cover the "basin" or tank. It consists of chicken wire stretched across the top of the tank, and over this, a wooden or metal frame is set.

3. Litter to fill the litter bed. This may be excelsior, sawdust, dried cornstalks or other plant material. Anything will do, in fact, provided it does not decay too quickly and will keep moist. It is in this bed that the plants to be grown are set.

4. An air space between the surface of the nutrient solution and the bottom of the litter bed.

5. Or, in addition to the air space, an automatic stirrer inserted in the solution of the "basin."

6. A means for spraying the litter bed to maintain the desired moisture conditions.[12]

7. A means of keeping the plants from sinking through the litter bed into the solution below, as they grow older, or for keeping them in place until their roots make proper contact with the nutrient solution.

8. A means for testing changes in concentration of the solution, as well as changes in acidity. A technically trained individual for doing this.

The remarkable success attained by the author of this system deserves serious study by any operator of a hydroponicum.

Probably no one has consistently secured as high productivity with both flowers and vegetables as has Professor Gericke with this system and his special technique for operating it.

Its chief difficulty is the delicacy of operation required in maintaining the litter bed in proper condition.

The chief virtue of this system is its lack of mechanical incumbrances, and its versatility for growing a variety of crops under skilled hands.

B. THE AGGREGATE SYSTEM. This system eliminates items two to seven of the Gericke System and adds the following:

1. A storage or mixing tank of reinforced concrete, waterproofed.

2. An "aggregate," which may be either sand, gravel or similar material. This is placed in the growing-tank. The plants are set or transplanted into this aggregate.

3. Either a system of containers for dropping the solution on top of the aggregate (sand), or a pumping and drainage system of pipes and tiles for flushing it at regular intervals.

4. An electrical motor for driving the pump.[13]

5. An available electrical current.

6. A timing device for keeping the pumping system in operation at the stated intervals.

7. A technician for handling and repairing the machinery.

In short, while this system eliminates some features of the Gericke System, it adds several more, thus adding to the cost of constructing and of operating. The principal features of the system were developed at Purdue and Ohio Universities, and the New Jersey Experiment Station, for research purposes. It is in many respects the ideal set-up for a hydroponicum for greenhouses. Its chief drawback for general use is the expense and technical experience required to operate it.

Both the Aggregate and the Gericke systems have been used extensively in growing vegetables and flowers. The United States army installed one or the other of these systems at various places during the last war. The system, as well as the manual describing its operation, were designed and written by Dr. Robert Withrow, mainly. The army adopted, rather than developed hydroponics.

C. THE SPESSARD SYSTEM. The essential features of this system are:

1. A growing-tank, with sand as the aggregate. This is the same as in the Aggregate System, but the tank is constructed differently.

2. A mixing-tank, or feeding-tank. It is of small capacity, and of a unit size to provide for a unit area of growing bed. The solution is not returned to it as in the Aggregate System, but it may, if so desired. Thus, all testing and pumping systems are eliminated. This tank and the growing tank are constructed, or may be constructed, as a single structure.[14]

The details of this system will be given in the following chapter. Its chief features are simplicity of construction and operation, flexibility in the use of aggregate, chemicals and fertilizers, adaptability to variations in weather conditions the world over, and low cost.

As far as it has been tested, it appears to be as productive of first class vegetables as the other systems.

Once constructed, it will last a century or more with little or no repair.

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CHAPTER 2

A Unit-Type Hydroponicum For General Use

I. Introduction

Before describing the Unit-Type Hydroponicum and how it operates, a word should be said about what it was designed to do, what objectives were considered to be of first importance, and what of secondary importance.

A. for whom intended. The system was designed for use by anyone interested first in growing food for his own use through his own efforts; second, for growing plants to be sold on the local market; third, for those who have reached that age when to be able to work at something without exhausting labor is a precious privilege.

Such people are located all over the world. There are regions where the population is greater than the land to support it. There are regions where it is too cold to bring plants to maturity because of a short season. There are other regions where tropical conditions make a garden both a difficult and a dangerous affair, because of pests and of disease-bearing organisms. If it is possible through a simple hydroponicum and technique to enable people in such regions to overcome the difficulties named, then, by proper education, a system such as the one proposed here should become an important contribution toward solving the problems mentioned.

B. primary requirements for a practical system. Since the system is not intended for research purposes, it should meet the following practical requirements:

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1. It should be so simple that anyone with skill enough to grow a garden might operate it successfully.

2. It should cost a reasonably small amount of money to enable a beginner to construct a large enough unit for learning the proper technique of operation.

3. Its operating costs should be low enough to enable the owner, after learning the technique, to repay the original cost of construction in one year of operation.

4. It should be operable under all sorts of weather conditions during a normal growing season, as well as under greenhouse conditions.

5. It should allow the use of a great variety of chemicals or ordinary fertilizers, since there is no standard set of such substances available at all places. It would be expected that chemical salts of proven worth would be preferable to an assortment of readily available fertilizers.

6. The technique of operation should be precise enough to assure a good crop regularly, yet not so precise as to increase costs of operation or of construction. For precision carried too far, is a liability rather than an asset.

7. It should take into account the fact that growing plants are tolerant of rather large variations in concentrations of the nutrient solution used, and of the kinds of chemicals offered them.

8. It should provide a rapid, simple and convenient means for measuring out the chemicals.

9. It should eliminate expensive mechanical details.

10. It should reduce chemical testing to the minimum.

11. Directions for operating it should be in the simplest language possible.

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II. Definition of Unit

A. Growing-Unit. The growing-unit is that area of the system in which the plants are grown. It consists of 200 square feet of growing space.

This is provided by a concrete (or other suitable material) bed or tank, 50 feet long and four feet wide, outside dimensions. The inside depth of the tank is eight inches. The walls are two inches thick. The bottom is also two inches thick, unless constructed in cold regions. In the latter case, it is reinforced and is three inches thick, being set on piers sunk to below the frost line, with a space between the ground surface and the tank bottom. In tropical regions also, the bottom of the tanks may be raised above the ground level to avoid insects and infestation with disease-producing organisms.

The unit may be built also as two 25-foot or five 10-foot tanks, with other dimensions as given.

The specifications for building the growing-unit are given in Figures 1-5, Section VI, page 27 of this chapter.

B. solution or nutrient unit. This is one 50-gallon barrel. This is chosen because it is a familiar unit to people of the United States and many other countries. It is also a simple fraction (1/5) of the physiological units commonly used, namely, 1,000 liters, or 1,000,000 grams, or five barrels of solution. Finally, one barrel of solution is the amount which will daily provide the nutrients required for one growing-unit, having 200 square feet overall area (see A), when fully planted. This was determined by expriment.

This amount of solution is calculated to give plants in one growing-unit their daily ration at the time of maximum requirements, which is near the peak of their growing period. For tomatoes, this amount would be sufficient for approxi-

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mately 130 plants in the unit area given above. Smaller plants would cover the same area, but would be more in number, of course.

The actual construction of the solution-unit provides for three barrels rather than one, for this reason: During the early growth of plants in the growing area less nutrient solution is required than when the plants are approaching maturity. Therefore, it is convenient to make up three barrels at a time, rather than one. A greater amount than this, experience has shown with this system, is undesirable. As the season progresses and the temperature increases, more and more water is given off by the plants. Therefore, although the daily ration of chemicals remains fixed, there has to be a provision for giving the plants more water. Since the minimum of solution in the tank is one barrel, and the total capacity is three, we have two barrels of extra water which may be provided if necessary in very hot dry weather. If the tank contains two barrels of solution, there still remains one barrel capacity for providing extra water at the time of feeding.

The dimensions of this nutrient-tank are, therefore: 34 inches long, 4 feet wide, and 28 inches high, outside dimensions, with 2-inch-thick walls.

Specifications for building this unit are given in Figures 1-5, page 27-30.

The unit, therefore, from the point of view of operation, consists of a feeding-unit and a growing-unit to form a single working whole. It may be redefined as a unit of solution (one barrel) which will adequately supply the growing-unit (200 square feet) with the proper amount of nutrient solution daily, when it is filled to capacity with plants at the time of maximum growth.

The two may be constructed in one piece, with the feeding-unit at one end of the growing-unit, or with the feeding-unit placed at the midway point between the ends of the growing-unit. The essential feature consists in having a growing area no larger than the barrel of solution will provide adequately. The size of the growing-unit was determined by experiment in the region of Conway, Arkansas. There is no apparent reason to suppose that it would vary from place to place.

In later discussions it will be the unit-as-a-whole, which will be considered. Once the operator learns how to operate one unit, he may then double or treble or otherwise enlarge his plant as desired. The details remain the same whether one or a hundred or more units are built.

III. Selection of Site for One Unit

A. light. The unit may be placed anywhere that the amount of light available is sufficient for the growing needs of the particular kinds of plants to be selected. Vegetables require more light, as a rule, than do flowers. It is a common misconception that in hydroponics one may use an attic, a cellar, a closet or any sort of ill-lighted place. This is not so.

Many believe also that there is need of ultra-violet light. It is the blue and orange-red portions of what we call white light which are used in greatest amounts by green plants. The amount of light, both as to length of daylight period and intensity, is of great importance. Some plants do best when the days are short, others when they are long. Fortunately, most vegetables offer no difficulty on this score. Plants may, to a certain extent, protect themselves against too intense light and ultra-violet light.

When the light intensity is too low, the leaves tend to enlarge, as though in an effort to make the green material

(chlorophyll) cover as large an area as possible. When the light is too intense, the leaves may wilt or even burn, because of internal disturbances connected with using the substances given them through their roots.

B. water supply. The unit must be placed where a constant supply of water is available. This may be near a faucet, beside a pond or stream, or below a dam through which the water may be led to the hydroponicum by pipe or other means. The ideal locations of large hydroponica would be on the hillsides below the great water-control projects throughout the world.

I estimate that the *maximal* amount of water required to operate my own system, regardless of the number of units built, is 22 gallons per square foot of growing area per 100-day growing period. Most crops mature in this time. This may be put in another way, by saying that the amount required is the equivalent of 36 inches of rainfall. If we take a region in which the annual rainfall is 10 inches, then by collecting the rainfall over an area 3.6 times the size of one unit and storing it for use as needed, enough will be available for growing one crop on one unit. Again, in a desert with an annual rainfall of six inches, the water collected and stored from an area of only 1,200 square feet should be sufficient to grow a crop on one unit. In other words, by proper water conservation, growing vegetables for home use by hydroponic methods is practicable. It is the common practice in many regions to thus conserve water for household use. An extension of this idea to include a small hydroponicum could scarcely be called a difficulty. There is hardly a site in the world, where people must live, with less than six inches of rain annually.

This estimate of the amount of water required may be lowered in regions where the rainfall is heavy. Indeed, the rainfall may so seriously dilute the nutrient solution as to

bring about temporary starvation of the plants, unless proper precautions are taken.

C. shading. In hot arid regions, in order to reduce evaporation, as well as to avoid excessive sunlight, shading is necessary for some crops. Likewise, an occasional sprinkling of the surface of the growing-unit with water may be necessary to prevent accumulation of chemicals at the surface, and to wash out wastes which tend to collect in the sand, in the absence of rainfall.

D. AERATION OF PLANTS. The supply of oxygen for the roots is discussed elsewhere. But there are regions where the air is very humid. In such places the unit must be so located as to allow free circulation of the air through the leaves. Overcrowding of the plants must be avoided, or fungi will attack the plants and destroy them rapidly. There is another reason, quite as important as the first, namely, making conditions favorable for the evaporation of water (transpiration) from the under surface of the leaves. If this does not occur, the plant has difficulty in obtaining a sufficient amount of the chemicals offered them, and fail to use properly what they do get. Circulation of air, if not excessively violent, is necessary.

E. DIRECTION OF UNIT. There is no reason for believing that the unit must be placed north and south rather than in any other direction. But it should be obvious that in whatever direction it runs, it is necessary to observe that tall plants must not be allowed to shade low plants, unless specifically desirable.

IV. Materials Required for One Unit

For the convenience of those who wish to make an estimate of what it would cost to build one complete unit in their particular locality, an exact list of the materials required is given here.

A. Slightly more than two cubic yards of mixed cement and four cubic yards of washed sand for filling finished growing unit.

B. Lumber: 210 linear feet of eight-inch-wide and 216 linear feet of 10-inch-wide material for forms; 100 linear feet of two-inch by four-inch material for bracing forms; 100 linear feet of one-inch by three-inch material for screeds or guides; 14 linear feet of one-inch by two-inch material for making screen to cover the nutrient-unit tank.

C. Two pounds of nails, assorted sizes; one box of carpet tacks. Metal screening, with mesh fine enough to keep out mosquitoes; one piece 48 inches by 30 inches.

D. Three 3-inch nipples; one 8-inch nipple; one elbow; two caps for nipples; two hydrant faucets. The diameter of the nipples should be small enough to accommodate the faucet thread.

E. Ten gallons of asphalt paint (not tar).

F. Ten pounds of glass wool, or some material which will allow water to seep through freely, but not allow sand to pass through. Newspaper will serve. Rock wool may be too alkaline.

G. One hundred pounds of chemicals. It may be necessary to buy this much of each major kind, used in the formula chosen.

H. One glass graduate for measuring acid. One acid tester, with color indicator and extra rolls of paper for renewal. One tin can 10 c.m. by 5.8 c.m. diameter for measuring chemicals.

I. One five-gallon bucket. One garden hose.

J. Ten 7-foot cedar or other posts for building a superstructure for tieing up crops like pole beans, cucumbers, and tomatoes; about 200 feet of poles or lumber for frame attached to the posts; 150 seven-foot-long pieces of wire of weight used in an ordinary fence, to provide each plant a support suspended from the cross poles or frame.

It is assumed that the operator will have the unit built by a contractor, who will know how to make forms for pouring concrete. If the operator does this work himself, he will have to know, of course, how such forms are constructed.

The materials listed provide for making one unit and operating it for one crop. Only a partial renewal of the chemical supply will be required for further operation.

The reader should be reminded that if he has to fight insects and fungi, proper spraying materials will also be required to save the crop grown, precisely as in ordinary gardening.

A greenhouse is unnecessary, unless the operator wishes to lengthen his growing season by transplanting, or wishes to grow plants early, or desires to have produce for use when the outside temperature is low. For transplanting, I use tin cans large enough to allow the plants to become sufficiently well-advanced that one month of growing time outside is gained. The capacity of such cans is about one gallon. It requires one can for each plant to be transplanted. There are several advantages to be gained through the use of this size can rather than some other. First, tomatoes may be transplanted when in full bloom, without harming the root system. Second, they may be spaced to prevent crowding, simply by removing every other can. When not used for transplanting purposes they come in handy on many occasions. The most important use is to substitute them for the large growing-unit or cement tank. Plants such as beans, tomatoes, and beets may be left in this size can and brought to maturity simply by pouring the nutrient solution over the contents by means of either a dipper or a hose. See the tin-can technique for details, Chapter 4.

V. Principles on Which Total Unit Works

The unit is designed to meet four practical working requirements. These are: First, providing adequate air for absorption through the roots; second, providing adequate supply of chemical solution to the roots; third, meeting additional water requirements as needed; fourth, maintaining the proper acidity of the solution about the roots in the growing area.

By means of two sand-retaining walls set on the bottom of the growing-unit, there are provided two open channels, one of which may be filled with solution, which then flows under the retaining wall, while the other receives the solution as it flows from the sand area, and serves as a drain towards the end of the growing-tank and away from the feeding-unit. The flow is regulated by properly sloping the bottom of the growing-unit from the first, or feeding-channel, to the second, or drain-channel on the opposite side.

The solution is delivered into the feeding-channel from the feeding-unit by means either of a faucet set in the wall of the feeding-unit eight inches above the bottom, or by means of a nipple set in the wall of, and at the bottom of the feeding-tank. See Figures 2 and 4, pages 27 and 29. The latter is the quickest way to deliver the solution into the feeding-channel. The former allows the solution to be aerated as it falls the eight inches into the feeding-channel and the faucet is less likely to become clogged with debris from the feeding tank.

Aeration is provided partly as described above, and partly by alternately allowing the solution to fill the spaces between

the particles of sand through capillarity, then permitting air to percolate downward from the surface as the water is used up, or drains away.

The unit type of hydroponicum differs from the types mentioned in the first chapter in several important respects. First, the solution is delivered fresh to the plants each day, and is not used over again. This may seem to be a waste. However, if a solution is made up in large quantity and used repeatedly, all of it must be thrown away sooner or later and be replaced. In the unit type under consideration we throw it all away, as in the case of the other systems, but do it gradually rather than at one time. The principal advantage gained is in not having to make chemical tests. When the feeding is done skillfully, it is found that only a few gallons are discarded daily, but in doing so the effect of a constant flow of nutrient is approached. Also, the acidity of the solution in the regions of the roots is kept fairly constant, a very important point to be considered. However, over prolonged periods of extremely high temperature, it is more economical to sprinkle the sand surface with water occasionally, or with slightly acidulated solution by means of a hose attached to the faucet of the feeding tank.

Another difference to be noted is the lack of any extra provision for root aeration. No pumping at regular intervals and no air bubbling system is required. It has been found that during very hot weather the solution may be left in both the feeding and drain channels to a depth of two inches for a whole daylight period without becoming stale, and without the plants showing injury from oxygen shortage. However, this is not advisable, since the solution around the roots, lacking a flow movement, tends to become alkaline within a day or so. In periods of wet weather this trouble is not encountered.

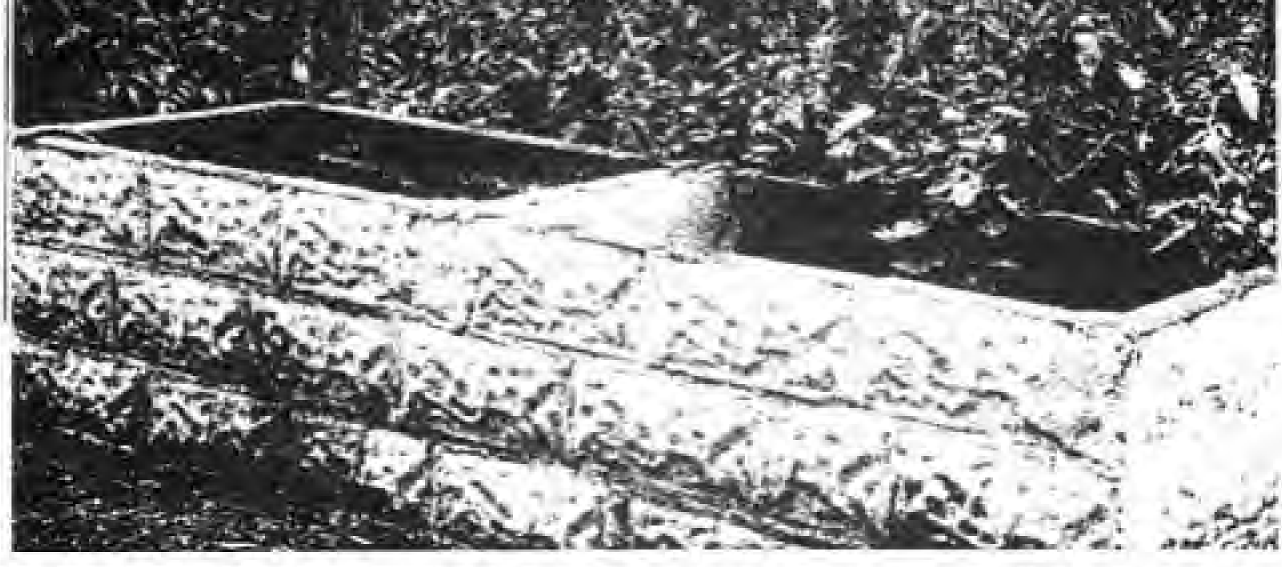

ILLUSTRATION 3. View of double feeding-tank. This shows the feeding-tanks at one end of the growing units. Photographed by Mr. Roy Bruce.

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VI. Structural Details of Complete Unit

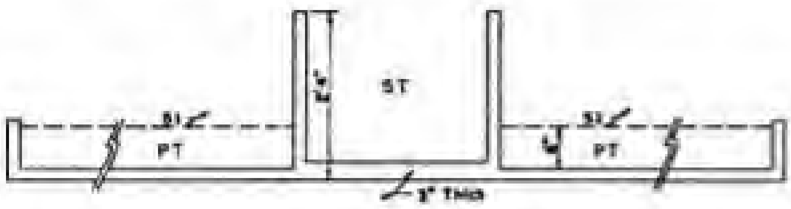

Figure 1. This shows a lengthwise section of the unit, through the middle. Each growing-unit (P.T.) is 25 feet long, with the end walls and side walls (not shown) eight inches high inside and 10 inches high outside. The solution tank (S.T.) is 34 inches long, running with the bottom of the whole unit, and 28 inches high, outside dimensions. The width is considered as running crosswise with the growing-unit, which is four feet, outside dimensions. (S.L.), sand level.

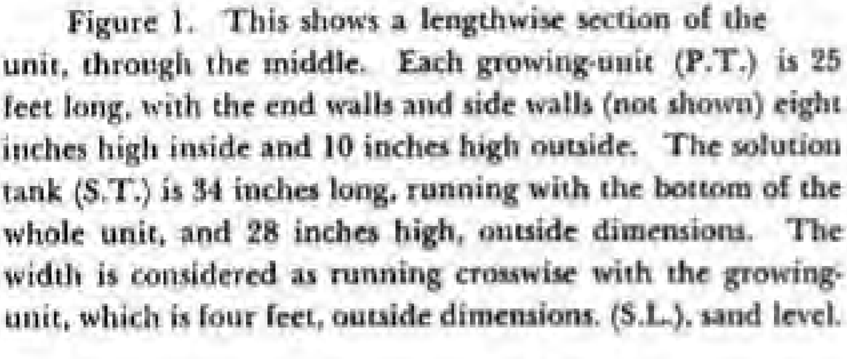

Figure 2. This shows a lengthwise section through the feeding-channel side of the unit, with a faucet (F.) and a capped nipple (D.N.) leading from the feeding-tank to each of the two feeding-channels, each 25 feet long.

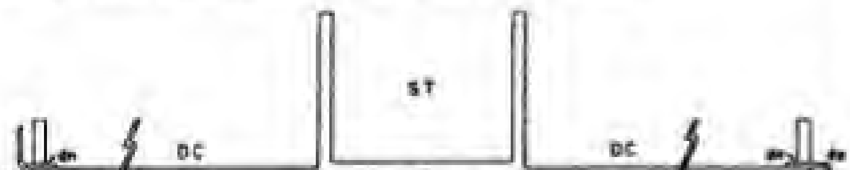

Figure 3. This shows a lengthwise section through drain-channel (D.C.) side of the growing unit, with a nipple (D.N.),

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and an eight-inch nipple attached to this. This makes an adjustable structure which provides for both opening and closing the drain. In the upright position, (U.P.) as shown in the sketch, the drain is closed, and the tank may be filled with sterilizing solution, water, or nutrient-solution as desired. In case of continuous rainfall, the outside nipple may be lowered so that its opening is an inch or so above the inside bottom of the unit. This allows for an overflow in case of sudden rain, and also permits a certain amount of solution to remain around the roots of the plants constantly. At such times, by increasing the concentration of the solution in the feeding-unit, or by scattering some ordinary garden fertilizer over the surface of the sand, the growing plants survive very wet spells nicely. This of course conserves the water, and lowers the estimate given in (III. B).

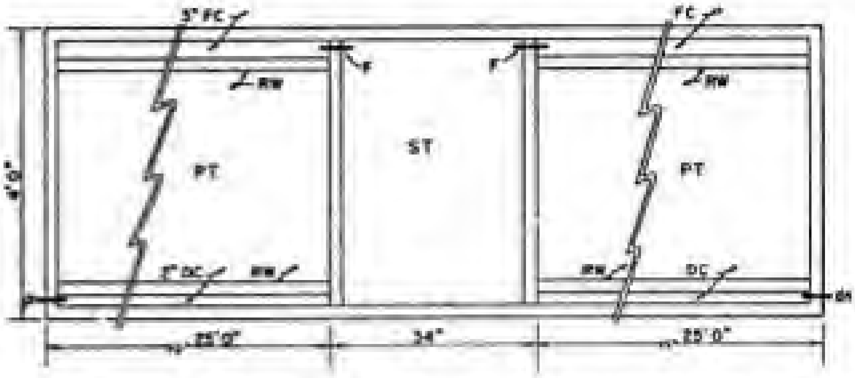

Figure 4. This shows the unit as a whole as seen looking down on it. The retaining walls (R.W.) are made of four-foot slabs of cement, one to two inches thick. These are set on the bottom of the tank and hold the sand in place, while allowing the solution to flow underneath them and over the bottom of the growing-unit. In case sand flows under them, or between the joints, glass wool, or paper, or asphalt roofing must be used to seal them loosely, being careful to permit a free flow of solution under them. See (S), Fig. 5. This is of

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utmost importance. The retaining-wall should be so placed as to allow a feeding-channel (F.C.) three inches wide, and the drain-channel (D.C.) one inch wide. A little extra space in the feeding-channel, at the place where the feeding faucet and nipple below it come through the solution-tank wall, is very convenient. It permits free use of the hand, a pair of pliers or small wrench. The retaining-wall is held in place by the proper use of spreaders, made of any convenient material. Brickbats are excellent for this. The use of spreaders may be avoided by tilting the retaining-wall against the tank-wall. If this is done the slabs should be made 9 inches high.

Figure 5. This shows two cross-sections of the growing-unit with the bottom sloping ½-inch across from the feeding-channel (F.C.) to the drain-channel (D.C.). The space between the retaining-walls is filled with sand, which settles down about two inches after being wetted thoroughly, to its final level. This makes the sand depth six inches and allows a two-inch space above the sand for preventing splashing of the sand out of the bed during a heavy rain.

In (A) the normal arrangement of feeding and draining is given. In (C) is shown a variation of (A), in which two open-bottom troughs (T) are sunk down the length of the growing-unit. These troughs offer a very convenient method for introducing the nutrient-solution. It flows downward, increasing aeration of the roots and aids in replacing any highly concentrated solution which may accumulate near the surface. It also distributes the solution more evenly to all the plants. This arrangement is especially effective when

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the bottom of the growing-bed is made to slope both ways from the middle to the sides, making both channels, draining-channels. This arrangement is preferable to that in (A) in hot, dry regions. The feeding-channel is unnecessary if the troughs are used. (B), detail of draining-channel.

VII. Functional Details of Complete Unit

Let us now see how the unit works in operation. Let us assume that the growing-unit is filled with sand, is planted, and that the plants are of size requiring feeding. Let us assume also that the feeding-unit is provided with nutrient-solution, and full enough to make a feeding.

First, either the faucet or the cap on the nipple in the wall of the feeding-unit (Figure 2) is opened. If both sections of the growing-unit are to be fed, of course both faucets will be opened. The solution flows down the feeding-channel (Figures 2 and 4) until it is full, as shown in Figure 5A at F. C. The solution flows under the retaining-wall, out of the feeding-channel, into the sand-filled area of the growing-unit. Here it spreads by capillarity in all directions through the sand and comes into contact with the roots of the plants growing in the sand.

From the sand area the solution finally flows under the opposite retaining-wall and into the drain-channel, Figures 3 and 4. If the drain-nipple (D. N. Figure 3) is in the up-position, the solution will flow into the drain-channel until it is ½-inch deeper on that side of the growing-unit than on the feeding-channel side. When the drain-nipple (D. N.) is in the down-position, all excess solution not taken up by the sand and the roots will drain out of the unit.

The faucet at the feeding-unit is closed when the feeding-channel is full, or when any other desired amount has been introduced into it.

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In the event that the growing-unit is provided with the troughs (T, Figure 5, C), the colution is introduced into them rather than into the feeding-channel.

In the event that the plants growing on the feeding-channel side grow more rapidly than those on the drain-channel side, it means that the slope across the growing-unit was not correct for the type of sand used. In that event, two solutions of this difficulty are possible. Either the trough (T) in Figure 5 B may be added or a cross-channel from the feeding-channel to the drain-channel may be cut through the retaining-walls and sand, straight across from where the faucet is located. Thus feeding can be done in both channels at the same time by keeping the drain-nipple (D. N.), Figure 3, closed until the amount of solution introduced is taken up by the sand and roots, and the channels then emptied of any unused solution. Care must be taken to see that the drain-nipple is then returned either to open or overflow position so that the growing-unit will not be flooded in the event of a big rain.

The feeding-unit is filled, of course, either from a water main faucet, by gravity through pipes from a pond, by pumping from a well, or by hand, according to the conveniences available.

The most economical arrangement for conserving the water supply is that shown in Figure 5, C, page 30.

This chapter ends with information on how the unit itself operates. The next chapter will tell how to operate it. In other words, we have been discussing the mechanics of the unit. Now we must deal with something which has to do with the judgment of the one who tries to make the machine work.

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CHAPTER 3

How to Operate the Unit-Type Hydroponicum

In order not to frighten the beginner who is seriously interested in building and operating successfully a unit type or any other type of hydroponicum, all technical details have been reserved for later chapters. Nevertheless, such things may not be put off indefinitely, if one is to increase his understanding of what is going on and what he is really trying to do. It will be assumed that he is anxious, perhaps over-anxious, to begin growing something in the hydroponicum he has set up. Very well, let us see how one goes about growing a crop of tomatoes in a unit type of hydroponicum such as has been described in the last chapter.

I. Chemicals You May Use

In Table I, page 68, you will find a list of chemical substances which have been used by one expert or another in making up satisfactory formulas for your use. In Chart 2, page 99, you will find some of these as used in various formulas. As a test, we will choose Formula VIII for our present use: Potassium chloride, sodium nitrate, ammonium nitrate, monocalcium phosphate, magnesium sulphate, lime and nitric acid for the bulk chemicals. For the trace elements we shall use ferric ammonium citrate, manganese chloride, boric acid, molybdic acid, copper sulphate (blue vitriol), and zinc sulphate. These will give us everything the plant needs. We shall assume that you have all these

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on hand and have the acid testing supplies mentioned in the last chapter, page 22.

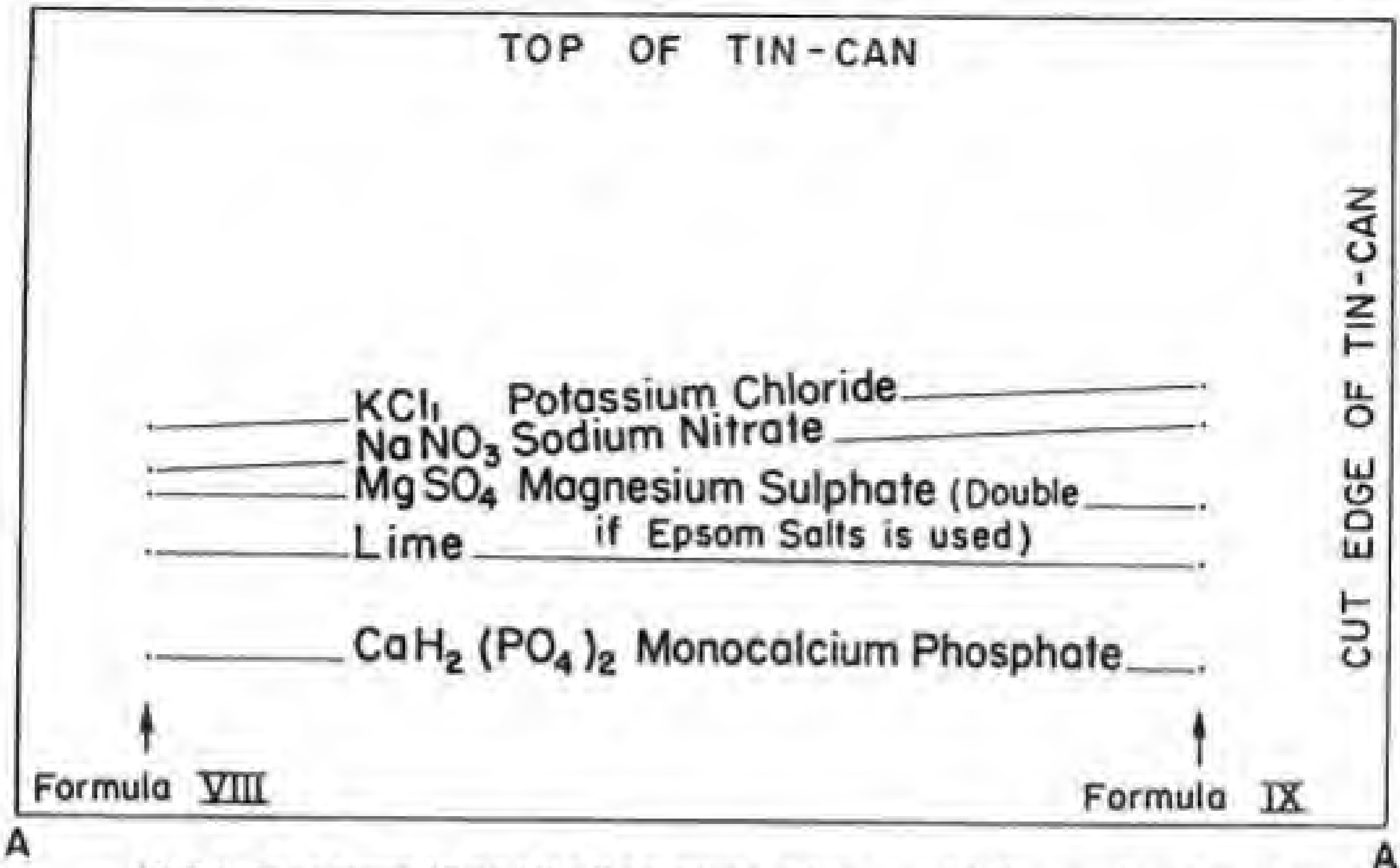

FIGURE 6. Tin can measures 100 m.m high x 58 m.m. diameter. Cut out a copy of the drawing, and wrap it around any can just large enough to allow the edges to come together. To use, punch a hole at each level indicated. For each chemical, fill the can from the bottom up to the hole, and empty. Repeat until all the salts have been measured. Dump them all into a barrel of water, stir, test for acidity (see text), and let stand six hours.

II. A Practical Method for Measuring Out Chemicals

The following method is to be used for mixing up one barrel of solution, which is the unit defined in the last chapter. It is based on the idea that a given weight of a chemical will have approximately the same volume regardless of atmospheric moisture which it picks up and loses from time to time.

I use a tin can 5.8 centimeters in diameter, and 10 c.m. high. Each chemical was weighed out according to the formula and its volume marked on the side of the can by punching a hole through the tin. Thus a chart showing the level of each volume of chemical used is easily made. The can is filled to the desired level determined for each chemical used. It is better to have a can for each formula. But the formula should be marked on the can.

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See Chart 2, page 99. The amount of nitric acid required to neutralize the lime would be about 20 cc.

Once the cylinder is prepared it is used as follows: It is filled to the level of the 20 mm. line with monocalcium phosphate. This is then poured out into a container of convenient size. Next, the can is filled with lime to the 33 mm. level for lime. The can is again emptied. The operation is complete when each chemical is thus measured out in its turn. The order of measuring is not important. Incidentally, one may use any size cylinder, no matter how much larger, and mix up any quantity desired so long as the levels remain as given. The whole would then have to be mixed very thoroughly, however, before using. I frequently mix up 100 pounds at a time, including trace elements, except iron. If this is done, slightly less than one pound of the mixture would be used for each barrel of solution made up. But let us proceed with making up one barrel of solution, by adding the trace elements.

For copper, use two or three drops of solution made by dissolving two pieces of copper sulphate the size of a pea in a quart of water. For molybdenum, use enough of molybdic acid powder to cover the period of this sentence. Do the same with zinc sulphate for providing the required zinc. Of, if you have an old wash tub or bucket filled with wood ashes which are covered with water, a spoonful of this will do. Or, in most cases, it might be just as well not to bother about zinc. Enough boron will be supplied if you ucover the word boron with boric acid crystals or borax. Enough manganese chloride or manganese sulphate to cover the word "acid" will be sufficient for the amount of manganese desired. For iron, enough ferric ammonium citrate or ferrous sulphate to cover the word "ammonium," would be sufficient to prevent iron deficiency in most cases.

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All these chemicals, *except the iron*, are now put into the barrel of water and stirred. It is perhaps best to put the acid into the water before any of the other chemicals are added, although it may be done afterwards. However, never put acid on the undissolved chemicals. Also, *never put water into the acid*. This is particularly true when sulphuric acid is used for it gets very hot when it is mixed with water. The

acid used here is to neutralize the lime. To decide exactly how much to use, make a preliminary test. Dissolve the lime you measured out, in a gallon of water. Then add acid slowly, stirring it frequently. Test with the paper after each stirring. When the paper shows a *p*H of 6.5 you are through (see III below). Note exactly how much acid was used. That is the amount to use. It should be around 20 cc. if nitric acid is used, and 10 cc. when sulphuric acid is used for Formula IX.

III. Adjusting for Acidity

You now come to a very delicate problem. You must adjust the solution to its proper acidity. Don't do this until six hours after mixing. This is called "pee-aich," *p*H, and is indicated as 4.5, 5.6, 6.0, 7.0, and so on. You are aiming to adjust the acidity to 6.5. Above 7.0 the solution is alkaline and few plants will grow in it. Below 7.0 it is acid. Most plants prefer a slightly acid solution. None will do well if the solution is at 4.0 for a very long period. It should be stated that the acidity of the solution about the roots does not remain 6.5 for very long. Whether it becomes acid or alkaline depends on several factors. However, we shall begin by giving the plants a solution reading 6.5, or slightly less, and later test it as it comes out of the growing unit or by sinking small wells down in the sand deep enough to fill with some of the solution about the roots themselves and then test this solution.

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The solution in the barrel is adjusted by adding acid drop by drop until the paper reads 6.5 after thorough stirring. If too much acid has been used, the mistake may be corrected with a little lime or lye water or wood ashes. It takes practice to make this adjustment easily. In practice, the solution should be made up the evening before it is to be used. The acid adjustment may then be made the following morning. If you complete the steps given in Section II correctly, no adjustment will be necessary. But check.

The iron is added to the solution just before feeding and after the adjustment for acidity has been completed. Otherwise it will precipitate out of solution partly and the plants will show signs of iron starvation in spite of the fact that it has been used regularly. Ferric ammonium citrate is preferable to ferrous sulphate for this reason.

You now have a barrel of solution made up according to Formula VIII, which I used during the past season and which produced on one 200-square-foot growing unit 746 pounds of marketable tomatoes between April 1st, when the plants were transplanted to the growing-unit, and July 12, 1947, when the bed was replanted in Lima beans.

IV. Use Made of Ammonium Nitrate

The reader may have noted that ammonium nitrate was not included in the levels of measurement on the tin can, although it was selected to be used. This chemical will be used in our test to add nitrogen as desired. Ammonium nitrate is a liquid. The form sold in bags has a coating which rubs off easily when used on cultivated soil. In a hydroponicum one is never quite sure just when it becomes available after being put into water. It is used because the ammonium part is more quickly used by the plant than the nitrate part, when protein is being made. For this reason it

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is difficult to manage. It is easily possible to give too much nitrogen at once by the use of this chemical. I have found, however, that if one adds gradually increasing amounts, beginning with 5 mm. in the can or cylinder, no harm is done. The very maximum would be 100 mm. This is done only on clear days, as these grow longer, when the temperature is in the eighties or nineties. I never use it on dark days. The whole problem of feeding nitrogen is discussed in the more technical Chapter 6, Section IV, page 78.

V. Preparing the Growing-Unit for Transplanting

Before the tomatoes are transplanted to the growing-unit the sand in it must first be properly prepared. If washed sand was used, it is first made to settle down by flooding the growing-unit with tap water. It is then thoroughly drained. Properly done, this leaves the sand in a level condition. After draining, the sand is allowed to dry out at the surface.

The sand is then thoroughly wetted with nutrient-solution from the solution-tank unit. The details of this procedure are given in Chapter 2, Section VII, page 31. However, a word must be said here. You are now face to face with several problems. First, you want to supply enough water and chemicals to the roots of each plant for proper growth. Second, you want to allow enough oxygen to get to the roots so that they will not suffocate. This means that you must not allow the roots to be covered with the solution for too long a time. Remember that without oxygen a plant cannot live and everything else we may do is useless unless we provide this element.

This is accomplished by filling the feeding-channel full enough so that with the drain-nipple closed, enough will flow under the retaining-walls to soak up the sand to within a quarter-inch of the surface, and allow none to remain in

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the feeding-channel, and only a very little in the drain-channel. Since the bottom of the growing-unit slopes one-half-inch across, and since the sand on the feeding side has the first opportunity to soak up the solution, a little time must be allowed for the sand on the drain side to soak up its full amount. Otherwise, the plants on one side will receive more of the chemicals than on the other and will grow faster. After this time has passed what little solution remains in the drain channel may be allowed to pass out. It may be collected and returned to the solution-tank if desired. I rarely do this because it is less expensive to discard a little every day than to bother testing it, since in time all of it has to be discarded anyway if it is reused.

VI. Transplanting to the Growing Unit

If you have bought your tomato plants from a nurseryman or if you have grown them from seed yourself, the plants are transplanted as you would do in a garden. I make it a practice to grow my own plants from seed, transplant them into gallon cans three-fourths full of a mixture of compost and sand, or of dirt and sand, and transplant from these to the growing-unit. The entire contents of the can is transplanted. The roots are thus not damaged, and some time is saved. The plants are set just deep enough to have the roots, with the contents of the can, extend down to the moisture levels of the sand, but not with the stem more than an inch below the surface. I find that deeper planting causes the old roots to die, thus causing a delay until new roots are formed. I have not found that deep planting makes for sturdier and more productive plants as some growers claim.

If there is danger of the stems rotting at the surface, as sometimes happens in humid weather, it helps to wrap each stem with a small wad of rock wool soaked in a little [40] copper sulphate, sulphur and lime, at the region barely below the sand level.

The plants are set in three rows down the length of the growing unit. They are spaced about 14 inches in the row, the plant of one row alternating with that of another row. This permits the use of about 130 plants to the growing-unit.

Once the transplanting is finished, the drain-nipple is then closed, and the growing-unit thoroughly wetted again with nutrient-solution as described in Section IV above.

VII. Inducing Roots to Grow Downward

After the plants are properly set in the growing area and fed, the next problem is to induce the roots to grow as near the bottom of the sand as possible. If the sand is kept wet at the surface, the lower roots will die of suffocation and all the roots will spread out just beneath the surface of the sand. If this is allowed to occur, many difficulties will be encountered later. To avoid this situation we proceed as follows:

First, the plants are not fed again after transplanting until the surface of the sand has begun to dry out slightly. If it happens that the season turns out to be very wet at this time, it may be impossible to do anything to prevent the surface spreading of the new roots. But let us assume that the season is, at this point, reasonably favorable. As the top portion of the sand becomes less wet, the roots will tend to follow the water down and may even go as far as the bottom of the cement tank. During this period the plants are given just enough solution to keep the bottom of the two channels moist but without allowing the solution to stand in them. By running a little into the feeding-channel three times a day, the trick is accomplished. It takes at least one week to do this.

[41] Cauliflower, for example, set out in mid-summer when the temperature was 95 degrees F., and the sand surface 110 degrees F. for several hours during the day, recovered without serious wilting in 24 hours. After that time they endured full sunlight with a daily maximum temperature of 95-105 degrees F. for two months. The plants were not previously hardened but were grown in sand on the nutrient-solution used in this discussion and transplanted without the loss of roots. These plants were given Formula VIII for the first two months and brought to maturity on Formula IX. Cucumbers, grown in another unit at the same time, were similarly treated. They were given a little ammonium nitrate and some extra potassium chloride as fruit began to form. Sample plants of both the cauliflower and the cucumber showed, when pulled up, that the roots had developed nicely and toward the bottom. It should be pointed out, however, that surface roots must also be developed. The upper roots serve to absorb the oxygen, while the lower roots serve as feeding roots.

Thus we achieve a situation like that in a wet garden, where by ridging up the rows, the surface layers provide oxygen and some chemicals, while the lower and wetter layers provide water and chemicals.

VIII. Feeding Schedule

Beginners want to know first, what to feed the plant, and second, how much. Third, they want to know how often. In the Gericke system feeding is continuous. In the aggregate system, it is either continuous or every eight hours. In my own system it is once a day. In all the systems the plants are feeding continuously. It is the number of times devoted to renewing the solution that varies from system to system. To go further on this point would require that we become technical.

[42] If the reader is prepared to understand that no matter what system is used, certain changes must be made in applying the basic technique employed, because of variable factors, we may proceed. Rain dilutes the solution in the growing area. High winds and temperature cause plants to take out the water faster than the chemicals are taken out of the nutrient-solution. Dark, cloudy periods upset the plant's needs for one kind of element or another. Thus the number of feedings is linked up somewhat with a number of factors. By striking for an average and hoping for a little luck, given a sound formula and a barrel of solution properly prepared,

we may expect rather fair results.

The general schedule then, keeping the above remarks in mind, is as follows:

A. FEED EACH MORNING. Use enough solution to make the sand moist to very near the sand surface after the feeding-channel becomes emptied. If this requires a whole barrel, use that amount. If it requires only a quarter of that amount, that is sufficient. The plant cannot use any more than the sand will hold. Also it cannot use what you carelessly let run out of the drain by insisting on using up the whole barrel of solution. On the other hand, don't be stingy. If for some reason the sand requires two barrels to wet it properly, give it two. (See B 4 below.) You have used enough, generally, by the time the solution reaches across to the drain channel.

B. VARIATIONS. There are several situations which require changing this daily routine which is followed, ordinarily, rain or shine.

1. *When the plants are small,* and their roots have not yet spread out to their normal extent, less water and chemicals are being taken out of the growing-unit. Therefore, you may not need to feed more than once a week during this initial period.[43]

ILLUSTRATION 4. A view of one growing-unit showing the feeding-channel to the right and the drain-channel to the left. Corn is growing as a second crop in the foreground, while the crop of eggplants, one of which is shown in Illustration 4, is growing in the background. This is not a desirable arrangement, since the food requirements for the two kinds of plants differ. The corn turned out to be a failure. Photograph by Mr. Charles A. Stuck.

2. *The weather may change,*[44] so that the temperature is in the 50's and 60's. Your plants will do nothing. Daily feeding then would not only be wasteful but it might kill the plants. Feed only enough to keep the plants from wilting.

3. *You might be faced with a week of heavy rains,* even before you have succeeded in getting the roots to grow down (see VII). You may do several things to get out of this difficulty. First, double or treble the amount of each chemical you put into one barrel and feed as usual. In this event, you would keep the opening of the drain nipple at a partial up-position, so that two or three inches of solution would remain in the bottom of the growing-unit, and at the same time allow the excess rainwater to flow out before it floods the growing-unit surface. Or you may leave the drain-nipple open at down position and sprinkle some good grade garden fertilizer, such as 4-12-4, over the surface of the sand between the plants. Since the rain dissolves this slowly, and at the same time brings oxygen into the sand, the plants are both fed and aerated. In this event, you simply omit all use of your feeding-unit until the weather clears up. Or thirdly, you may feed as usual (see A) by keeping the drain-nipple at the overflow-position. This is what I do, if the roots are fully developed, and have grown down to near the bottom of the growing-unit.

4. *Water loss.* The plant uses up water independently of the chemicals it uses. As it grows larger, and as the daily temperature rises, more and more water passes through the plant and out into the air through the leaves (transpiration). Water also evaporates from the growing-unit. At the same time, however, the plant is also taking up the chemicals more rapidly. How then are we to keep the concentration around the roots favorable? Again, a full explanation here would require that we become technical.[45] It is enough to say that if you increase the concentration suddenly, the roots will be killed. If you decrease it suddenly, the roots will not be hurt as quickly. What we try to do is to keep enough water in the solution so that the chemicals in it will not become too highly concentrated for a long period, and second, to keep enough chemicals in the water so that the concentration will not be excessively dilute. This brings us to the practical way for solving this problem.

If you note the moisture of the surface sand carefully, you will come upon a time when one barrel of solution is not enough to make it moist. Here is where the three-barrel feeding tank comes in handy. Make up two barrels in the feeding or solution tank according to directions in II and

III above. Now dilute this by filling up the tank to its three-barrel capacity. This gives you two barrels of food and one extra barrel of water. Now feed as usual. If this dilution is still not enough to satisfy the demand for extra water, make up one barrel, and fill to capacity. This makes your concentration only one-third what it would be normally. But the plants will soon take up the extra water offered them. This is, of course, a matter of using your head rather than a rule. If you had a garden you would use a hose for watering. Since you have a hydroponicum instead of soil to handle, you simply add the water at the time you give the plants their daily food ration.

5. *Change of acidity in the growing-unit.* The acidity of the solution in the region of the roots changes. This may become alkaline for several reasons. One of them may be that you have not discarded quite enough of the used solution. Another may be that not enough solution has been used to allow each spot in the growing area to be flushed with fresh solution. To test this, dig small wells in the sand deep enough to allow them to collect a little solution soon 46 after filling the feeding-channel. Test this solution with your acid testing paper. It will show 6.5 or slightly less in all probability. By adding a little acid to the solution before it is fed into the feeding-channel, so that the paper shows a *p*H of 4.5 that is, a little more acid than what is wanted for proper growth, then, by the time the solution reaches the roots, the *p*H will be correct. It is the *p*H, or acidity, in the growing-unit that is important, rather than the *p*H in the solution-tank. Regular feeding is most important in keeping the *p*H correct, as well as proper dilution of the solution, to take care of water loss by transpiration and evaportion.

6. *High temperature and bright light.* You may have a month or more of high temperature when the thermometer hovers above the hundred mark. This will require that you not only dilute the solution to provide the extra water required, but may require that you feed morning, noon, and evening. Plants sometimes wilt, even though they have plenty of water available. But plants also wilt if not enough water is available. This is partly due to the fact that in the region of the roots, the chemicals accumulate, particularly at the surface of the sand.

Several things may be done. First, the growing-unit may be sprinkled with water in the late evening. Second, the solution may be fed over the surface of the sand between the plants by means of a sprinkling-can, a bucket or a hose. Enough would be put on in this way to have a few gallons flow out of the drain-nipple. This is also a very good way to correct the acidity in the solution of the growing-unit if this is found necessary.

7. Finally, you may be growing a plant like a cucumber, which requires more water than a tomato. In that event you would feed the unit at least twice a day, and probably three times, being careful, of course, to dilute the 47 solution so as not to overfeed the plant with an excessive amount of the chemicals.

Let us sum up by saying that you are aiming to provide one unit, when fully planted and when the plants are growing to maturity, with between one-half pound and one pound of chemicals daily, on the average. This is less when the plants are young and small, and more when they are mature. The directions, if followed, will provide for these requirements quite satisfactorily. Or, putting it another way, a tomato plant will not use up more than a half pound of chemicals during its normal growing season. Our task is to give it not more than it can use to mature properly, but to give it enough so that it grows and bears fruit. That this schedule is satisfactory, is borne out by the production report given above in Section III of this chapter, last paragraph.

IX. Use of Your Time

The actual time and labor required to operate the unit is very small. Much more time is taken in tending the crop, and crops differ in the amount of attention needed. But a few words should be said here on how to conserve what time is needed for tending the hydroponicum itself. Following is my procedure.

First, the growing unit is examined to estimate how much solution might be required. Next, the solution is tested for acidity. Then the faucets are all opened for the six units I now have in operation. I generally use the nipple at the bottom of the solution-unit, since the feeding-trough fills in about three minutes through it. Each unit varies from the others, to some extent, in the time required for the solution to pass over to the drain side. As soon as this happens, I turn off the faucet for that unit and lift up the drain-nipple after a gallon or two have escaped into the discard. 48 It takes about twenty minutes to go the rounds of the six units, waiting to have the solution flow into them, then closing the faucets.

During this time I generally find an opportunity to measure out, in separate containers, the chemicals for the next mixing and for each of the six units. As soon as one unit is fed, I note how much was used up. If exactly one barrel, and if no more feeding will be done that day, I turn on the water, put in the chemicals, and do something else while the tank is being filled.

Some hours later, perhaps six, I open the drain-nipple to down-position, allowing whatever solution has not been used up to escape, thereby assisting aeration of the roots. Thus, no time is wasted. Rather, the same time is used for several jobs, or for just sweet rest.

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ILLUSTRATION 5. The tin-can hydroponicum of the Apolo Pipe Manufacturing Company, as constructed by Mr. A. S. Jacobsen, at Rio de Janerio, Brasil. The plants growing in the cans are soybeans. The cans are discarded carbide containers cut in half.

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CHAPTER 4

The Tin Can Hydroponicum

After all, a large growing tank is little more than a glorified tin can. The main difference between the two is in having the solution offered to the plant, delivered through the bottom of the tank, while that offered to the plant growing in a tin can is delivered at the surface of the sand, or soil, in which it is growing.

Everyone is familiar with the use of flower pots and of tin cans for growing plants. But not all are familiar with the fact that nutrient-solutions, made up by any chosen formula, may be used as successfully by this means as by the use of a large hydroponicum such as has been described. In fact, it is this sort of small unit that is used quite extensively for research purposes at the New Jersey Experiment Station particularly. This method is ideal for the householder who has only room for a few plants in his back yard, on a roof, or in any other small area which is easily accessible.

This technique is described for those who would like to grow a few tomato plants, some Kentucky Wonder beans, a cucumber vine, lettuce or beets near their kitchen door. The cans may be set at any convenient place where there is adequate light. The plants themselves will cover up otherwise ugly spots about the home while doing their work of providing some food for the family. It is an ideal way to learn the first principles of hydroponics.[51]

I. Materials Needed

1. One tin can of a little less than one-gallon capacity, for each plant to be grown. Seven or eight ½-inch holes are punched through the bottoms with a road pick or other blunt instrument. The cans are then painted well with asphalt paint and allowed to dry thoroughly.

2. Materials for filling each can to within two inches of the top, after settling. This may be good garden soil which does not pack when watered, pure sand, half sand and dirt, half dirt (or sand) and well rotted compost or old plant debris, excelsior and sawdust, or even rock wool. I use some kind of rotted organic material, mixed with sand and any kind of dirt, equal parts of each. This is mixed very thoroughly with a shovel. The cans are all filled at once from the pile, which is kept renewed continuously. Filling the cans to the top, then watering them, settles the material down to about the proper level. The cans are then sterilized, if desired, and stacked for use as needed. The material used is accumulations from old weed patches, the lawn and the kitchen, piled up, sprinkled with a little lime and wood ashes, or better still, with a little fertilizer having in it some nitrogen and phosphorus. If this is allowed to rot for six months it is good for use. It should be kept wet, but the rain should not be allowed to wash it.

3. Asphalt paint, for dipping the cans or painting them as indicated in (1).

4. The chemicals as given in either Chapters 3 or 7.

5. The acid-testing equipment as given in Chapter 2, IV-H, or Chapter 9.

The only difference between this type of hydroponicum and the unit type is the use of individual cans as a substitute for the growing-unit. The solution is kept in a barrel, [52] painted with asphalt paint, and is delivered by hand to each can by means of a dipper, or a garden hose attached to the faucet set in the barrel.

II. Procedure

1. Plant the seed in the middle of the can as prepared in (I). It is best to plant two or three. When they come up, pull up all but the best one.

2. Press the dirt down with the fingers about one inch from the edge of the can, so that a shallow trench runs around the now slightly raised place where the seed was planted. Fill this trench with a dipper of water or of nutrient-solution from the barrel. Use enough so that a few drops come through the bottom.

3. Collect some of the solution that has dripped through the bottom of the can in a saucer (clean and without trace of soap). Test this for acidity as explained in the last chapter. This should be 6.5. If it is more than this, flush out the can with solution made acid to slightly below 6.5, or even as low as 4.5. Do this until the reading of the acidity of the solution coming through the bottom is 6.5.

4. Do not water any more until the plants come up. If

the cans are protected from direct sunlight the material will not dry out, and thus prevent germination of the seed.

5. Dust the place where you intend to set the cans with a little DDT powder. Dust the top of the material in the can also.

6. Now arrange the cans together and cover them as a protection from heavy rain.

7. After three days inspect for signs of germination. It may take fourteen days for some seeds to come through the

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soil. As soon as germination begins, space the cans as desired at the place where they are to remain. Protect them from dogs and birds by chicken wire.

8. As soon as the plants are up, begin feeding them a pint of solution once a day. Use more if necessary to keep them from wilting. Dilute with water.

9. As the plants mature, space them so that none will crowd another, or shade it. Protect the cans from becoming too hot through direct light hitting them for long periods. A little hay, straw, or newspaper will be sufficient to protect them, if laid up against the side of the can exposed to the sun.

10. Climbing plants will have to be furnished with proper support.

11. When you pull up a beet or a head of lettuce, or any other plant, stir up the contents of the can, add a little more if necessary, and plant another seed of something. In this way, you may begin your can garden inside the house two weeks to a month earlier in the spring, and carry it through the whole summer. I always have 25 cans of sweet corn ready to set outside after the danger of frost is past. These supply me with roasting ears during the month before the crop started outside comes into bearing. It is thus possible to have a continuous supply of corn, lettuce, beets and beans, with cauliflower, celery and a cucumber vine in addition.

It takes about twenty minutes a day to feed 100 such individual-can hydroponica, by means of a garden hose attached to the barrel of solution. Most people waste ten times this amount of time about the home.

If the cans are set on the lawn, they must not be moved. For the roots will fill the can and, sooner or later, find a hole through the bottom and start going down into the ground.

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After the growing season is over, all the cans are emptied on the compost heap. Next spring this material is used again.

Beets and beet greens, which are particularly high in vitamin A, may be kept throughout the summer, and remain tender, if kept partially shaded. Lettuce will produce large crisp and green leaves if treated similarly. The green lettuce is richer in vitamin than is head lettuce. Care must be taken to inspect for aphids and other insect pests.

Here is a type of hydroponicum that even a child may operate and enjoy. If a constant drip is provided for adding the solution to each can individually, an added interest is furnished.

This method is recommended particularly for certain regions in the United States and Canada where mining is going on. There, gardens are frequently destroyed by a sudden shift in wind, which covers the garden with poisonous fumes sufficiently long to kill the plants. It is possible to stagger crops in such a way as to have a new one going, on a small scale of course, if such an accident occurs. Again, such plants as tomatoes, if properly supported, may be moved quickly to a safe spot until the danger from gas is over. This would be impossible, of course, for large groups of plants. But there are many householders who have an interest in only a few plants, but who would also like to save them in an emergency. This method will serve their purpose nicely. I have found it possible to move 200 cans in a half hour, to protect plants from an unexpected frost. It is worth the little trouble it takes. Incidentally, a number of families in mining regions in Canada are now trying out this method for saving their little, but precious, gardens. It was at their suggestion that the remarks above have been offered.

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CHAPTER 5

Essential Elements--Their Chemical Sources

1. Introduction

Since what we are really trying to do is to supply the plant factory with raw materials for manufacturing proteins, fats, carbohydrates, vitamins and the like, it is clear that out of the many possible kinds of substances available for this purpose we must sift out those most agreeable to the plants we wish to grow. We do not select a chemical because we fancy it, but rather because the plant requires it.

The list of chemicals necessary for growing plants successfully is not large. Shive and others have used as few as three. But to do this requires much skill indeed. Generally, four or five bulk chemicals, and as many for the trace elements, are sufficient. The list given in Tables I and II is larger than required to make up one formula. The reason for this is simple. Some chemicals are available, while others, equally serviceable, are not. Therefore, if the reader masters the few technical details required, he may make up a satisfactory formula, using what chemicals are available to him, anywhere in the world.

Plants do not discriminate between substances offered them, by means of taste. To them, nitrogen is nitrogen, whether it comes from ammonia, nitrate or urine. But they do differ much, both as to chemical needs and the conditions under which the chemicals are offered to them. It is not generally appreciated that there is as much difference

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between a tomato and a radish as there is between a man and a horse. Men occasionally eat out of a horse trough, and horses have been known to eat food off of a man's table. We are not surprised to find, however, that as a rule each gets along better on the kinds of victuals to which their bodies are, by nature, accustomed. But we are surprised to find, strangely enough, that while some plants do well planted side by side, others do not. Why? This is a complicated question, and the answer has, in all probability, little to do with the phases of the moon. One plant may want more light than another; one may require more acid than another; one may require an amount of boron that it would kill another. So it goes. Would one feed a baby pork chops, because its father, near by, required them? Would an expectant mother be allowed the same diet as a girl of six years? Let us cease this chatter in favor of something more important.

Many people have the impression that the chemicals used in hydroponics are dangerous to human health. It is human nature to fear what is not understood. In this instance, the difficulty comes partly from the inability to reconcile reports on cancer research, with human consumption of food; and partly from reports by individuals engaged in forms of what might be called fetish farming. The latter give out the impression that plants grown in certain specialized forms of compost contain no chemicals, and, therefore, cannot harm people who eat the plants so grown. The crusade against "chemical fertilizers" is on. Chemicals are supposed to be so "unnatural" as to be a positive danger. It is time that this propaganda be countered with more complete information. If a "little knowledge is a dangerous thing," it might be added that a little ignorance may be a calamity. As a matter of fact, it would be difficult to find anything more natural than a chemical. It would be impossible to have a compost heap without them.

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Your body is made up of chemical elements. Nothing else is in it. So also is that of a plant. It matters not whether the plant is grown in a hydroponicum, a garden, or in a compost heap! Either of these may be deficient in having certain essential elements, and either may furnish the plant with too much of a given element. The consequence in either instance would be either a tasteless product or one having less health value than desirable. It is not the way you grow a plant that gives it value or makes it harmful, but rather the chemicals which that particular method is able to supply. Growing plants with the use of compost is one of the most reliable methods for growing plants ever devised. It requires a high degree of skill to practice this method successfully. But it is entirely false to say that compost-grown vegetables contain no chemicals.

This fear of "chemicals" is very real in the minds of many. A correspondent from one of our seaboard cities writes: "My goodness, Doctor, these chemicals frighten me! What if I happened to drink some of the solution in your hydroponicum?" When assured that there is nothing of an atomic-bomb nature, or poison pill, in a head of lettuce, a roasting ear, or a tomato grown in a hydroponicum, the good lady very sensibly settled down to the quiet regime of gardening the "new way."

Birds and insects drink out of a hydroponicum and appear to suffer no harm. I never do. I prefer to take my minerals and other elements in the less raw state of carbohydrates, proteins, and vitamins; and in the form of lettuce, fruit juice or tomato. The latter demand their Epsom salts. I do not.

What, then, are the elements which a plant must have in order to function as a living thing? They are: carbon, hydrogen, oxygen, nitrogen, potassium magnesium, manganese,

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phosphorus, sulphur, calcium, iron, copper, molybdenum, boron, and zinc. The number is fifteen. Some would say more, some less. But to keep blood pressure normal, let us keep out of the argument, and stick to the fifteen. That satisfies most plants—why not us? One of the fifteen may be doubtful. It is said that the lack of molybdenum causes flower-drop. To decide the question is more difficult than pronouncing the "d" in the word. Also, it should be made clear that flower-drop may be due to a number of things. One should not jump to the conclusion, therefore, that the addition of molybdenum to his nutrient solution will stop this evil. One has to investigate, in order to decide which of a number of possibilities is the correct one. A woman may, for example, lose her teeth either through improper eating habits, decay, or simply by having them knocked out by her lover, in the light of the moon, as a sign of engagement.

This bit of humor is intended also as a mite of warning. You will be sure to have some trouble with plants if you work with them very long. So many things have been said about the elements plants need that you are likely to feel, in the face of your difficulties, some element must be missing in the diet. You will in all likelihood jump to the wrong conclusion, and proceed to kill them with an overdose of this or that. Look first, in case of trouble, for lack of oxygen about the roots, and the *p*H of the solution about them. Or, perhaps, you may be either overfeeding them or underfeeding.

We come now to the first real stumbling block for most people interested in hydroponics, and who have no knowledge of chemistry. What are "elements," "chemicals," and the like? It is said that "troubles come not singlehanded, but in battalions." So it is with elements. They come not singly, as a rule, but in those "battalions" or combinations commonly called "compounds" by chemists. We do not give plants "elements" on which to ruminate, but compounds of elements. It is their job to get the elements out of these compounds as best they can. They are experts at doing this. But they can't take out an element if it isn't in the compound we offer it. First, let us get our terms cleared up.

II. Definitions of Terms

The chemist uses the terms "chemical" and "elements." The farmer and gardener use the term "fertilizer." The plant physiologist, who is responsible for deciding what substances may be used in hydroponics, uses the term "essential element." Without being technical about it, let us attempt to make a practical distinction between them.

A. chemical. This is a loose expression, meaning either an element or a compound of several elements. Water, for example, is a compound chemical, made up of the two elements hydrogen and oxygen. Other examples, to mention only a few, are urea and carbon dioxide, which are compounds, and sulphur, nitrogen, and gold, which are elements. Perhaps the simplest way to say what is meant by an element, is to put it the way a child would, namely, one of those substances used to make a chemical compound. Since this is not intended as a treatise on chemistry, we shall let the matter stand at that.

B. fertilizer. A fertilizer, on the other hand, may be anything which has in it at least something a plant may take in and use for making its food. In other words, it contains some substance used for building the plant or enables it to do its work. It is neither a chemical compound nor a chemical element. It is a mixture of many chemicals, and is made up to satisfy the legal requirements for distributing to gardeners and farmers just three essential elements. The only essential elements ordinarily officially accounted for in "fertilizer" are nitrogen, phosphorus and potassium.

C. essential element. This term means exactly what it says. It is an element essential to the well-being of a plant or an animal. It is an element for which no other may be substituted. Not only does it have to be available but it must also be present in a definitely minimal amount. This needs explanation. Suppose, that to grow at all, a certain number of corn plants, for example, require, as determined by experiment, at least 26 pounds of nitrogen. They would grow better, obviously, if 27 pounds were made available. They would not grow at all if only 25 pounds and 15.99 ounces were available. In other words, although the essential element nitrogen is present in our hypothetical experiment, still the corn must die because it lacks 0.01 of an ounce of having just enough nitrogen to stay alive. In practice, if a plant refuses to grow, one simply puts enough "fertilizer" on the soil to make it grow. Two mistakes are possible. If too much of a good thing is added, the plant, not knowing a thing about balanced diets, may make a hog of itself, and suffer accordingly. If the rule of the minimum is ignored by the grower, the plant will die in adolescence. In either case the operator is out of luck, and the corn crop is "trumped" in the midst of a promising career.

Fortunately for the operator of a hydroponicum, the techniques involved, as well as the laboratory findings on this point, make it fairly easy to supply each plant with the minimal amounts of the elements needed. This is often extremely difficult to attain in soil farming. It is sometimes impossible.

At this point a word should be said regarding the essential elements for man. It is man and his domesticated animals that eat the plants grown. But it is probably not an exaggeration to state that more is known today about a plant's requirements for essential elements than about man's. Because a plant requires certain elements, and in certain minimal amounts, it does not follow that the same requirements hold for man. When Nebuchadnezzar took to eating grass, the silicon which is a necessary part of the vitamin-rich type of forage he ate, was of no earthly use to the king of the Babylonians. Since it is known that man does require certain essential elements, and that the soils of the world are in many cases deficient in those elements, it follows that if these may be supplied in a hydroponicum, then the food thus grown must be preferable to that grown on land deficient in such elements.

III. Chemicals vs. "Fertilizers" Comparative Cost

It would seem to be an imposition to a respectable plant to offer it materials it cannot use. It is a helpless sort of thing, this creature we call a plant. Just as a dog cannot resist taking into its blood stream a bit of arsenic which has been mixed with its meat and swallowed, so cannot a plant keep from taking into its system the odds and ends of chemical debris thrown at it in manure, compost and "fertilizer." Much care has been exercised in the past to reduce this offensive material to a minimum. But unfortunately it cannot be entirely avoided. There is, however, another aspect to this question of useless material, namely, the cost.

Let us now reduce the cost of "fertilizer" and food-grade chemicals to common terms, and compare their values. The common term is the amount of essential element bought in each case, since that and that alone is what the plant uses.

A. ESSENTIAL ELEMENTS IN "FERTILIZER". A 100-pound bag of fertilizer is marked, let us say, 4-12-4. This means

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that there are 20 pounds of fertilizer and 80 pounds of other material in the bag. Of the 20 pounds of fertilizer, there are four of nitrogen, 12 of a phosphorus compound, and four of a potassium compound. Only 5.3 pounds of the phosphorus compound is actually phosphorus. The remaining 6.7 pounds is oxygen. In the case of the potassium compound there are 2.8 pounds of potassium and 1.2 pounds of oxygen. Of the total 20 pounds, therefore, four are nitrogen, 2.8 are phosphorus, 5.3 are potassium, 7.9 are oxygen.

It so happens that the plant uses very little, if any, of all this oxygen. This essential element is taken in mainly through the roots as water, or as the element itself dissolved in the water. Therefore, the amount of this element found in our bag of fertilizer must be considered as so much waste. This leaves us, then, but 12.1 pounds of essential elements which may be used by the plant.

If the 100 pounds of fertilizer cost $4.00, or four cents a pound, the 12.1 pounds of essential elements also cost $4.00, or 33 cents a pound. In other words, by buying our essential elements as fertilizer, we pay much more per pound than is generally believed.

B. ESSENTIAL ELEMENTS IN "CHEMICALS". Let us buy these in 100-pound lots as in the case of our purchase of fertilizer. A quotation for one bag, furnishing potassium and nitrogen, with only two pounds of miscellaneous waste instead of 80, and 47 pounds of useless oxygen, leaving 51 pounds of potassium and nitrogen, may be bought for $12.00. The essential elements therefore cost 21 cents a pound. To get the phosphorus for comparison, another bag containing 2 pounds of miscellaneous waste, 58 pounds of useless oxygen, and 40 pounds of the essential elements, phosphorus and calcium, may be bought for $8.50. The essential elements in the bag cost, therefore, 22 cents a pound.

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Of the 200 pounds of chemicals bought, we acquired 51 pounds of potassium and nitrogen and 40 pounds of phosphorus and calcium, making 91 pounds in all of useful material, for $21.50. To buy the same amount of essential elements as fertilizer would cost $30.03. Or putting it the other way around, for the same amount of money, one would get only 45 pounds of essential elements.

Obviously, if we are intending to grow our vegetables hydroponically, it is much cheaper to buy the essential elements as chemicals rather than as fertilizers.

Two conclusions might be drawn from the result of this calculation. First, it would appear offhand that the people of the United States who use fertilizer for their farms are paying twice as much as necessary. Second, it might appear that somebody is being gypped. Now let us see to what extent this is true or untrue.

Farmers and gardeners have at their disposal all the land about them. Land is mineral matter. If it contains essential elements, and if these are suitably mixed up with humus or the dead remains of plants and animals, and if, furthermore, this mixture is inhabited by minute living organisms, the land becomes soil, fit for growing plants. In other words, in good soil all the essential elements are present. The gardener or farmer has only to do his work properly, keep his soil in condition, and his plants will thrive as well as in the best hydroponicum ever invented. But the record shows that farmers in general, the world over, have not been clever enough to do this. It is an alarming fact that soil has deteriorated throughout the world during the rapid industrial development of the past two centuries. The consequence is that while farmers and gardeners do not have to buy all of their essential elements, they do have to purchase some of the most important of them. Of the fifteen named

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at the beginning of this chapter, most farming areas require that the plant producer supplement his soil's essential element content with purchased nitrogen, calcium, phosphorus, potassium, boron, manganese, sulphur and copper. In some regions, magnesium and zinc must be added to this list.

We are now in a position to decide whether or not the cost of essential elements is too high for the farmer; whether or not he is being imposed upon by those who sell him fertilizer. First, if the essential elements were delivered as chemicals to him, he would almost certainly burn up his crop. This has occurred. And, as a consequence, dealers in fertilizers have been sued successfully. In other words, in order to protect both the farmer from ruining his crop, and the dealer of fertilizer from being perpetually called into court, the essential elements must be mixed with a great deal of waste material. Obviously, then, the farmer is not necessarily being gypped. He is only paying the necessary freight imposed by an unfortunate circumstance. He who buys his mineral water in a bottle over a counter must pay more for it than he whose house rests by the spring.

This rather tedious discussion seems necessary, if we are to arrive at a reasonably true comparison between the costs of farming hydroponically and the usual way. For one of the important items is the cost of essential elements. If the gardener or farmer has to pay twice as much for essential elements because of unavoidable circumstances, then it would be part of national wisdom to grow food by some method where the cost of essential elements would not be conditioned by this circumstance. Hydroponics would appear to be that method. However, if the lower cost of essential elements is offset by unnecessary mechanical and technical expense then there can be no gain by adopting hydroponics. But let us leave this point for later discussion. So far as the cost of

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essential elements is concerned, hydroponics has the advantage over other methods of growing plants.

Not only from the cost angle would the operator of a hydroponicum use chemicals rather than fertilizers, but also from the point of view of safety. Manufacturers of fertilizers seem to feel that they are in possession of precious secrets. Actually, any second-rate chemist can determine without much trouble the kind and quantities of elements in any fertilizer ever mixed. It is to be hoped that this mediaeval attitude of imaginary secrecy may be educated out of the minds of those responsible for making available the essential elements required in all forms of agriculture.

In hydroponics, "fertilizers" may therefore be recommended only in an emergency. In a 100-pound bag of it, the 12-odd pounds of essential elements may be counted on. But it is just as likely to be chuck-full of plant poison. Any use made of it is possible only after experimenting with each "secret" kind, and long enough to determine how much of it a plant will endure before giving up the struggle. A further difficulty is encountered when one desires to double, let us say, his nitrogen without adding to his potassium. If the bag of fertilizer says 4-12-4 that is all the nitrogen which he can get out of it. If he wants eight of nitrogen, he must buy two bags. And if he does he must thereby take the potassium that goes with it. Buying chemicals gives him the chance to buy nitrogen without the potassium, if desired.

However, there are occasions when chemicals cannot be purchased. Then fertilizers must be used. It is necessary at times to make a compromise between what is desirable and what is practicable. During the war chemicals which were imported became suddenly unavailable. Those manufactured in this country became short of both nitrogen and phosphorus, since these two elements were required for

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ammunition. Since not all types of hydroponica permit the use of ordinary fertilizer, this point must be taken into consideration before adopting one for use.

IV. Chemicals Suitable for Use in a Hydroponicum

There are two types of chemicals which may be used in a hydroponicum, "pure" grade and "food" grade. It is assumed that the bulk of the chemicals used will be of food grade, and that when these are unobtainable, the pure grade will be substituted. The calculations shown in the tables will be made for both. In those cases where minute amounts are used, only pure grade chemicals are listed. In order that the operator may have a choice of several chemicals, in case the one desired may not be purchasable, several alternatives are given.

It is assumed that the reader is not a chemist. Therefore, the tables give only the information he needs to know in order either to interpret properly the formulas given in the following chapter, or to modify them to suit his own demands. In order to make it unnecessary for him to perform them, all necessary chemical calculations have been made and the results tabulated in the tables. The tables are therefore to be used as a handy reference rather than as a source for complicated calculations.

To manage the chemical aspects of a hydroponicum one has to understand only two things. First, he must know what chemical substances (or "salts," as the chemist calls them) furnish the essential elements that plants need. Second, he must know how much of each essential element it is possible to get in a given weight of the salt. This is what the tables show. The amounts are stated in grams. To convert to ounces multiply by 0.0352. As a further convenience, in the chapter on formulas, the amounts actu-

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ally used will be further reduced to practical volumes, in terms of a tin can. And for those in foreign countries, who have no acquaintance with this American household container of green peas and the like, drawings are made on paper for cutting out and making a container which is familiar. Everyone recognizes the rectangle and the cylinder, whether or not he knows grams or ounces. Thus, to use the formulas, the reader does not have to weigh. He needs only to take, as directed, a half can of this, a third of a can of that, a pinch of something else, and throw the amount into his barrel of water. It has been found that for all practical purposes the average plant grown has a tolerance for this variation. On the average, the operator's errors will cancel out, so far as the plant is concerned.

Since the essential elements required by plants may be available in a number of different chemical compounds or salts, the list given in Table I includes the number generally found in books on hydroponics, and in textbooks on plant physiology. The reader must now refer to Table I.

V. The Term for Measuring Concentration of Essential Elements—Parts per Million, or PPM

If, what we buy is either a fertilizer or a chemical, and if, what concerns the well-being of the plant is an essential element, then it seems sensible to agree on some easy way for deciding just how much of any essential element is to be found in a given portion of the substance we buy.

Since the earth weighs something, and since the earth is made up entirely of elements, then the elements must weigh something. But what? There is no way of knowing, except by weighing one against the other. This you won't have to do. It has been done long ago. Let us arrange

TABLE I.

CHEMICALS WHICH MAY BE USED, WITH AMOUNT OF ESSENTIAL ELEMENTS IN EACH

Column 1 Names of Chemicals and Symbols	Column 2 Relative weights in grams: A Pure-grade	Column 2: B Corrected for Column 3	Column 3 Percent pure of food-grade	Column 4 (Essential): N	P	K	Mg	Ca	S	O	H	(Waste): Na	Cl
				Relative weights in grams of elements in each of amounts given in column 2. (Read to right in each case.) See page 70 on how to use in calculating any formula.									
Ammonium nitrate, NH_4NO_3	80	82	98	28						48	4		
Calcium nitrate, $Ca(NO_3)_2$	164	180 200	90 70	28				40		96			
Nitric acid (measure in cc.), HNO_3, conc.	63	---	c.p.	14						48	1		
Potassium nitrate, KNO_3	101	110	95	14		39				48			
Sodium nitrate, $NaNO_3$	85	90	97	14						48		23	
Ammonium sulphate, $(NH_4)_2SO_4$	132	140	94	28					32	64	8		
Calcium sulphate, $CaSO_4$	136	136	c.p.					40	32	64			
Gypsum, $CaSO_4 . 2H_2O$	172	198	85					40	32	96	4		
Sulphuric acid (measure in cc.), H_2SO_4, conc.	98	---	c.p.						32	64	2		
Magnesium sulphate, $MgSO_4$	120	130	92				24		32	64			
Kieserite, $MgSO_4 . H_2O$	138	180	76				24		32	80	2		
Epsom salts, $MgSO_4 . 7H_2O$	246	260	45				24		32	176	14		
Potassium sulphate, K_2SO_4	174	200	90			78			32	64			
Monocalcium phosphate, $Ca(H_2PO_4)_2 . H_2O$	252	310 254	75 99		62			40		144	6		
Monopotassium phosphate, KH_2PO_4	136	140	97		31	39				64	2		
Monoammonium phosphate, $NH_4H_2PO_4$	115	150	85	14	31					64	6		
Potassium chloride, KCl	74	80	95			39							35
Lime, CaO	56	62	90(?)					40		16			
(Use with approximately 33 cc. nitric acid)													

THE TRACE ELEMENTS

				Fe	Mn	B	Cu	Zn	Mo
Ferric citrate, $FeC_6H_5O_7$	245	---	c.p.	56					
Ferric ammonium citrate, $FeNH_4C_6H_6O_7 . 3H_2O$	317	---	c.p.	56					
Ferrous sulphate, $FeSO_4 . 7H_2O$	292	---	c.p.	56					
Ferric chloride, $FeCl_3$	161	---	c.p.	56					
Manganese chloride, $MnCl_2$	126	---	c.p.		55				
Manganese sulphate, $Mn_2(SO_4)_3$	400	---	c.p.		110				
Boric acid, H_3BO_3	62	---	c.p.			11			
Copper sulphate, $CuSO_4 . 5H_2O$	249	---	c.p.				63		
Zinc sulphate, $ZnSO_4$	161	---	c.p.					65	
Molybdic acid, H_2MoO_4	162	---	c.p.						96

To convert to ounces, multiply by 0.0352g.

TABLE II.

AMOUNTS OF CHEMICALS FOR 1 PPM—100 PPM OF ESSENTIAL ELEMENTS

Weights given in grams. To convert to ounces, multiply by .0352. The ppm guide for five 50-gallon barrels. For 1 bbl., divide by 5. Refer to Table I for particulars about any chemical given here.

	% Pure	Grams of chemical salt required to make up: 1 ppm	2 ppm	5 ppm	10 ppm	50 ppm	100 ppm
NITROGEN, N.							
Ammonium nitrate	98%	2.85g	5.70g	14.25g	28.50g	142g	285g
Potassium nitrate	95	7.86	15.72	39.30	78.60	393	786
Calcium nitrate	90	6.43	12.86	32.15	64.30	314	643
	70	8.85	17.70	44.25	88.50	442	885
Sodium nitrate	97	6.00	12.00	30.00	60.00	300	600
Ammonium sulphate	94	5.00	10.00	25.00	50.00	250	500
Monoammonium phosphate	85	9.50	19.00	47.50	95.00	475	950
POTASSIUM, K.							
Potassium nitrate	95%	2.82g	5.64g	14.10g	28.20g	141g	282g
Potassium sulphate	90	2.55	5.10	12.75	25.50	128	255
Potassium chloride	95	2.05	4.10	10.25	20.50	103	206
Monopotassium phosphate	85	3.50	7.00	17.50	35.00	175	350
PHOSPHORUS, P.							
Monocalcium phosphate	75%	5.00g	10.00g	25.00g	50.00g	250g	500
	99	4.00	8.00	20.00	40.00	200	400
Monopotassium phosphate	97	4.50	9.00	22.50	45.00	221	450
Monoammonium phosphate	85	4.35	8.70	21.75	43.50	218	435
MAGNESIUM, Mg.							
Magnesium sulphate	92%	5.35g	10.70g	26.75g	53.50g	268g	535g
Kieserite	76	7.50	15.00	37.50	75.00	375	750
Epsom salts	45	10.85	21.70	54.25	108.50	543	1085
CALCIUM, Ca.							
Calcium nitrate	90%	4.50g	9.00g	22.50g	45.00g	225g	450g
	70	6.50	13.00	32.50	65.00	325	650
Calcium sulphate	c.p.	3.35	6.70	16.75	33.50	168	335
Gypsum	55	5.00	10.00	25.00	50.00	250	500
Monocalcium phosphate	75	7.75	15.50	38.75	77.50	388	775
	99	6.25	12.50	31.25	62.50	313	625
Lime	90(?)	1.50	3.00	7.50	15.00	75	150
SULPHUR, S.							
Ammonium sulphate	94%	4.50g	9.00g	22.50g	45.00g	225g	450g
Calcium sulphate	c.p.	4.20	8.40	21.50	43.00	215	420
Gypsum	85	6.00	12.00	30.00	60.00	300	600
Magnesium sulphate	92	4.05	8.10	20.25	40.50	203	405
Kieserite	76	5.50	11.00	27.50	55.00	275	550
Epsom salts	46	8.10	16.20	40.50	81.00	405	810
Potassium sulphate	90	6.25	12.50	31.25	62.50	312	625

THE TRACE ELEMENTS

IRON, Fe.					
Ferric citrate	c.p.	5.50g	11.10g	27.50g	55.00g
Ferric ammonium citrate	c.p.	5.60	11.20	28.00	56.00
Ferrous sulphate (copperas)	c.p.	5.00	10.00	25.00	50.00
Ferric chloride	c.p.	2.95	5.90	14.75	29.50
MANGANESE, Mn.					
Manganese chloride	c.p.	2.30	4.60	11.50	23.00
Manganese sulphate	c.p.	3.70	6.40	17.50	37.00
BORON, B.					
Boric acid	c.p.	5.50	11.10	27.50	55.00
Borax (used as boric acid)	c.p.	5.50	11.10	27.50	55.00
COPPER, Cu.					
Copper sulphate (blue vitriol)	c.p.	3.90	7.80	19.50	39.00
ZINC, Zn.					
Zinc sulphate	c.p.	2.49	4.98	12.45	24.90
MOLYBDENUM, Mo.					
Molybdic acid	c.p.	1.58	3.16	7.90	15.80

Use this table to find the amounts of any chemical to be weighed out, if you know how many parts per million of a given element is desired in any formula.

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the elements you will encounter in the order of their relative weights:

CHART 1. *Relative weights of chemical elements.*

Hydrogen, H	1	Magnesium, Mg	24	Manganese, Mn	55
Boron, B	11	Phosphorus, P	31	Iron, Fe	56
Carbon, C	12	Sulphur, S	32	Copper, Cu	63
Nitrogen, N	14	Chlorine, Cl	35	Zinc, Zn	65
Oxygen, O	16	Potassium, K	39	Molybdenum, Mo	96
Sodium, Na	23	Calcium, Ca	40		

Suppose, for example, we consider the chemical called nitric acid. Column 1 of Table I indicates that it consists of hydrogen, nitrogen, and oxygen. Furthermore, on observing the symbol for this compound we find that one part is H, one is N, and three are O. This means that by weight there would be 1 of hydrogen, 14 of nitrogen, and 3×16 or 48 of oxygen. The total would be, of course, 63. This number would then be the weight of nitric acid relative to that of any other chemical compound. For comparison, let us take potassium nitrate, found in the same column. In that compound there is no hydrogen. Instead, the element potassium occurs. The other two elements remain as in nitric acid. But, since potassium weighs 39, the relative weight of potassium nitrate is 39 for K, 14 for N, plus 3×16 or 48 for O, making a total of 101.

If you had 101 parts by weight of this substance, you would therefore have 39 parts of potassium, 14 parts of nitrogen, and 48 parts of oxygen. Now then, suppose you substitute the word "gram" for the word "part" in the previous sentence. Obviously, in every 101 grams of potassium nitrate you would have 39 grams of potassium, 14 grams of nitrogen, and 48 grams of oxygen.

Since we have adopted the word "gram" as synonymous with the word "part," a million parts of water would necessarily mean a million grams of water. How much are a
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million grams of water? About five barrels, each of 50-gallon capacity.

Suppose, finally, that we fill the five barrels with water, then throw in the 101 grams of potassium nitrate and let it dissolve. What concentration have we? Precisely 39 ppm of K, 14 ppm of N, and 48 ppm of O; or, if we consider the salt as a whole, 101 ppm of potassium nitrate.

Table I gives the relative weight for each chemical listed. In column 2-A the relative weight is for pure chemicals, and in column 2-B, the same for food-grade chemicals. In column 3 the percent of purity is stated, to identify chemicals when being purchased. In column 4 the weights of the elements found in the compounds are given. Note, for example, that kieserite, Epsom salts and magnesium sulphate are three different grades of the same thing. They differ in percent of purity, the water being considered as impurity. Note again that in column 4, under Mg, the same relative amount of magnesium is found, namely, 24. To get 24 grams of magnesium one would have to use 260 grams of Epsom salts (column 2-B), or 180 of keiserite, or only 130 grams of magnesium sulphate of 92% purity.

All this means that if the latter costs twice as much per pound as Epsom salts, since you would need to use only half as much of it as of Epsom salts, your final chemical bill for magnesium would be the same in both cases. But you would have to pay twice as much freight on the Epsom salts, which would make it cheaper to buy the purer chemical. Note also that in buying 24 parts of magnesium you are also buying 32 parts of sulphur, another essential element found in Table I, column 4-S.

You may wonder why we select a million rather than a thousand or billion grams of water as the basis for mixing our chemicals. The answer is simple. The plants prefer it.
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A little table salt (sodium chloride, NaCl) added to a glass of water improves its taste. But a tablespoon full of it would, upon being introduced to the stomach, cause that organ to assume a rebellious attitude. Experience shows that the roots of plants do their work of absorbing chemicals best when the total concentration is between 550 ppm and 2,000 ppm. In practice, formulas are made up so as to keep within these limits.

This brings up another point. All waters used in hydroponics commonly come from streams or lakes. These waters already have some salts dissolved in them. This may vary, as Gericke has pointed out, from 100 ppm to 3,000 ppm. This must therefore be taken into consideration in using a given formula. Some waters contain so much magnesium and calcium, for example, that it is unnecessary to put these essential elements into the solution. Indeed, to do so might be very harmful. If in doubt have the water tested, and make proper allowances.

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CHAPTER 6

Conceptions and Misconceptions Regarding Formulas

I. General Considerations

Let it be emphasized at once that, contrary to general belief, a formula for growing plants is not an equation. It is more of a guide than an unalterable rule. Many beginners seem to feel that if they only had a formula to go by they could, with certainty, grow anything from mushrooms to pineapples in the same jug of nutrient solution. Unfortunately, that is not the way of life, any more for a plant than for a happy human being. The best way to kill either the spirit or the body of a human being is to feed it the same thing day after day. So it is with a plant. The plant has no spiritual needs which must be satisfied, of course, but the needs of its body require one thing at one period of its life, and something else at another period. Some things it requires all the time. Until the operator of a hydroponicum realizes that he is dealing with a living, rather than with an inanimate thing, he can never quite realize that applying a formula is not as simple a thing as applying the law of gravity.

Therefore, let us consider some matters which form the basis for constructing the formulas to be given in Chapter 7. The reader will then be in a position to comprehend why they vary as they do.

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II. Requirements for Making a Formula for Growing Plants

A. THE PERFECT FORMULA. This exists only in the imagination of the novice. It implies that all plants require the same materials, and in equal amounts, throughout their whole lifetimes. Neither is true. It is only the novice who, as he approaches this business of growing plants hydroponically, makes as his first demand a formula that requires no thought in its application. He wants one that will meet the needs of any plant, at any time, in any place, whether it be spring or winter, and whether it be cloudy or sunny weather. There are those who find it profitable to have people believe this. Let it be restated, as a matter for emphasis, that there is no such thing as a perfect formula. The best we can hope to accomplish is a compromise between the plant's requirements, the kinds of chemicals available, and the climatic conditions existing where the plant is grown. For all practical purposes the best formula is the one that works.

B. PRACTICAL REQUIREMENTS FOR A GOOD FORMULA.

1. It must provide the essential elements as determined by testing in a reliable plant-physiology laboratory.

2. It must have in it the fewest possible waste elements.

3. Any unavoidable waste elements must be such that they will combine to form harmless substances, or will not prevent growth, or will not cause the solution about the roots to become acid or alkaline quickly.

4. It must be sufficiently balanced, so that one element will not interfere with another, or give the plant a chance to over-absorb a particular element it needs.

5. The number of chemicals used to provide the essential elements should be as few as possible.

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6. The total concentration, after the chemical ingredients have been dissolved in water, should be between 500 parts per million and 3,000 parts per million or lower.

7. It should allow the operator to grow several kinds of plants, when used, with a minimum of alteration as the season progresses.

The first requirement mentioned provides, of course, the things a plant needs in order to grow properly. The second is an economical proposition. One hates to pay money for waste. Besides, it takes less time to handle chemicals of this nature. The third applies to such cases as, for example, the use of potassium chloride and sodium nitrate instead of potassium nitrate. The latter is expensive, and sometimes cannot be bought, while the other two can. But these two contain chlorine and sodium, both of which are not required by plants, and both are poisonous in certain concentrations. If we use them in such a way that the two unite to make common table salt, we prevent their poisonous effects. But we also make, thereby, another substance which the plant cannot endure in very high concentrations. By washing this out of the sand occasionally, or letting the rain do it, we get along very nicely. Requirement four is a technical one and will not be discussed. As for the fifth, it also is concerned with economy of operation. The final requirement is inserted for making the feeding task less troublesome in running a hydroponicum. If one can be taught to grow several things at the same time without extra bother, he will the more easily learn the trick of making the more delicate changes required to grow some specialty, later.

III. Degree of Variation in Formulas

Another question frequently asked pertains to the fact that there is considerable variation, one way or another,

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between formulas. The beginner has difficulty in seeing why this should be so. Let us now pause to touch on this point.

A. EXTREMES IN VARIATION OF PPM. In looking over a great number of formulas, I was myself amazed to find that in actual use experts vary the ppm considerably, for one reason or another. The formulas presented in the next chapter are presented to you because they are conservative in this respect as well as of proven value. But let us see what extremes are possible, and yet have satisfactory results. Following is the range encountered: nitrogen, 50 to 500 ppm; potassium, 70 to 1,000 ppm; phosphorus, 10-154 ppm; calcium, 80 to 3,000 ppm; magnesium, 10 to 96 ppm; and sulphur, 13 to 140 ppm.

Now this does not mean that one may be careless about selecting a formula, or that one may simply put amounts of each chemical together indiscriminately, so long as one keeps within these limits. It means only that plants vary much in their needs for specific elements, and that under some conditions show more tolerance than under others.

B. EXPLANATION. Some of the formulas to be given became famous because they were surprisingly successful. That is sufficient reason for making any formula acceptable. They were successful, however, not because they differ, but in spite of it. They were constructed after many tedious trials in the laboratory. They represent the best of those trials. They should not be changed by the beginner, without sound reasons for doing so. On the other hand, they cannot be used successfully without little changes as the season and plant demand, and as these arise and are understood.

The variations in ppm represent thus, in part, variations in seasonal and plant needs; in part, pure experimentation

with respect both to tolerance, weather conditions and kinds of chemicals available for use; in part, an effort to keep the water balance as well as the balance between the sugar and nitrogen within the plant, satisfactory for best growth. Perhaps it should be added, that all these matters are concerned with the amount of oxygen available to the plant, as well as with maintaining the acidity and total concentration of the solution in which the plant is expected to grow.

In spite of recent publicity to the contrary, there is plenty of sound scientific and gardening proof that plants do differ with respect to the amounts of elements they use, their tolerance of soil or solution acidity, light requirements, temperature needs and periods of growth. While these matters may be considered as refinements, nevertheless they may not be ignored. They were all taken into consideration when the formulas to be given were constructed. This is important for the beginner to understand.

Referring back to the list of variations (see A), it will be noted that magnesium is varied least. And for a very good reason. This element, when in too high a concentration, interferes with the absorption of others. It interferes also with respiration, which, as we shall show later, is extremely important.

The greatest variation shown is in the use of calcium. This element has many uses inside the plant, among these, counteracting the poisonous effects of others. All in all, the differences between experimenters as to the ppm to be used is due not so much to a difference in opinion, I think, as to differences in conditions under which tests were made, and the kinds of plants used for investigation. For example, sand, gravel and water cultures present not quite the same conditions for growth, though they are all successful. Thus Gericke, who uses only nutrient solution around the roots

(except in the litter beds), keeps the ppm lower than do most workers who use sand and gravel in addition to the solution. Another factor in the variations observed is the fact that the total concentrations of the salts or chemicals must be kept within a definite range for best results. All the formulas conform to this requirement.

There is another important fact which might best be considered here. Of the elements mentioned above, the plants use more of nitrogen than any other. The others rank, with respect to relative amounts used, as follows: potassium, calcium, phosphorus, sulphur and magnesium. Notice that the ppm decided on do not run in this order. As an example, although the plant uses more nitrogen than calcium, the variation in the ppm of calcium is much greater than the variation for nitrogen.

All this discussion is intended to have the reader, first, respect the formula he attempts to use; second, not insist on considering the formula an unchangeable thing; and third, have him become conscious of the high degree of tolerance allowable, so that he will be less afraid to make changes when they become necessary. The Purdue and the New Jersey Experiment Station tests in particular seem to indicate that successful results in growing plants hydroponically are obtainable through use of a considerable range in the ppm of the various elements, as well as in the choice of the chemical compounds which provide them.

IV. PLANT'S USE OF ELEMENTS AS A FACTOR

Probably the plant's use of a given element is the most important factor in determining a formula. This is now obvious, although it was not always so. It was thought several hundred years ago that plants live on air and water. It was a very difficult thing to prove that in addition to

the four elements they get from these sources at least eleven others are obtained from the soil, or some chemical. Actually, 95 percent of the plant's body is made up of carbon, hydrogen, oxygen and nitrogen. It will be recalled that the first three are taken into the plant direct from either the air as carbon dioxide, or through the roots as water. The fourth, nitrogen, is taken in only through the roots in combination with other essential elements such as potassium and calcium. This leaves approximately only 4 percent of other elements which are all taken into the plant through the roots.

This is not the place to go into the many details of why these eleven elements, although used in such small amounts, can be so significant to plant life. There are writers who believe that we concern ourselves too much with them. But it is certain that if we try to strike a happy mean between too much and too little concern, we will in all likelihood be reasonably successful in growing plants.

One of the fascinating questions about plant life is what becomes of the elements plants take in. A little information on this point helps in deciding what to give a plant and why. Plants take in, sometimes, more than forty of the known elements. But they don't use all of them. Silicon, for example, is one element that is used by many plants, but it is not essential to all of them. Others are taken in, for example sodium, and simply tolerated. Let us now see what use is made by the more important of the essential elements, particularly of nitrogen.

A. NITROGEN. Only about one percent of the dry weight of a plant is nitrogen. But without that one percent there can be no protoplasm, the living stuff itself. Consider this as against the 44 percent of carbon, 45 percent of oxygen and the 6 percent of hydrogen in the same plant. Only five percent of the plant's needs for elements are gotten 80 from soil water or the nutrient tank in a hydroponicum. And of these five percent only one is nitrogen. Why then, we may ask, is the giving of nitrogen to a plant to be considered so difficult? Let us spend some time on this question.

1. FROM NITRATE TO PROTEIN. Laurie calls nitrogen the "push" element, rather aptly, I think. It is given to the plant in the form of nitrate (NO_3), such as potassium nitrate, sodium nitrate, or calcium nitrate; or it may be given in the form of ammonium (NH_4), such as ammonium sulphate or ammonium chloride and urea: or as both combined, as in ammonium nitrate. To be useful, the (NO_3) must be changed by chemical processes inside the plant to (NH_4), then to (NH_2) when finally it becomes part of the protein. This in turn is the principal constituent of protoplasm. Thus its importance.

In giving the plant nitrogen we must therefore consider that it takes the plant less time to change (NH_4) to (NH_2) than it does to change (NO_3) to (NH_4) to (NH_3) to (NH_2), for one process is more direct than the other. That is why we think of ammonium containing chemicals as a quicker source of nitrogen than the nitrate containing chemicals; a practical point of importance in cloudy weather, as we shall see.

Without nitrogen there can be no protein. Without protein there can be no protoplasm; which, in turn, means no growth and in the last analysis, death.

But to make protein, nitrogen is not enough. There also has to be present a specific amount of sugar. In addition, there must be a certain amount of heat available. How are these obtained? First, as you no doubt recall, the sugar is made out of carbon dioxide and water, when the plant is in sunlight. Thus, sugar has in it, carbon, hydrogen and 81 oxygen. Of these two, carbon and hydrogen may be burned to give the heat energy required to make the protein. Obviously, to get the job of making protein done, there must also be available an extra supply of oxygen, or the carbon and hydrogen cannot be burned. This is why it is so necessary for the operator of a hydroponicum to make sure that the roots of plants are properly aerated. After the final word has been said about growing plants in field, garden or hydroponicum, in the absence of oxygen, nothing of importance ever happens inside a plant but death. And that is highly undesirable to a grower of plants.

Proteins (and there are thousands if not millions of them) are found everywhere in the plant. If it were possible to remove everything but the proteins from the plants about your home, and keep such plants in their original places, you would still be able to recognize the lawn, the shade tree and the tomato patch. The forms of the plants would remain essentially the same. The same thing might be said with respect to the water and sugar (or carbohydrate) in the plant. It is instructive to imagine the plant body as a mass of branching water, standing alone. Indeed, the idea has been used elsewhere in this book, to help understand another point. But let us return to the nitrogen question.

2. GETTING NITROGEN INTO THE PLANTS. In giving the plant nitrogen it seems clear that we must keep in mind not only the supply of nitrogen in the solution but also the amount of light available and the oxygen supply. During this discussion we will add a fourth thing to be kept in mind, namely, the concentration of the solution.

In practical language, the plant uses its protein to grow. If the plant must make its own protein, and to do this sugar, oxygen and energy are required, it presents the grower with a very delicate problem to be solved. For on shady days 82 there will be less sugar produced than on sunny days. If he gives the plant the same dose of nitrogen day after day, regardless of the amount of light available, he will be running into one of two difficulties. On shady days, he may be giving the plant more nitrogen than can be used up, because of a shortage of sugar, and on sunny days his plants will have more sugar than is required to use up the amount of nitrogen he is giving the plant. In other words, one day he will be building up a sugar-poor and nitrogen-rich plant, while on the other he will be producing a sugar-rich and nitrogen-poor plant. The first will be a flabby, weakly affair, the latter a hard, woody, non-edible product.

The practical point to be considered is that nitrogen must be fed in relation to the amount of sunlight available. As the daily intensity of light increases, so must a little nitrogen be added to the solution offered the plant. The opposite is done on cloudy days or when the daily amount of light decreases. There are other factors, of course, but here we must keep our minds on one thing at a time, to avoid unnecessary confusion.

3. HOW NITROGEN SHORTAGE COMES ABOUT. There are two ways in which nitrogen scarcity may be brought about. The most obvious way is to fail to put enough of it into the solution, or, if one is a "dirt" gardener, on the soil. But the

second cause is more subtle. It has to do with the total concentration of the solution into which we have put the nitrogen with other chemicals.

Everyone knows that in a concentrated solution there is less water than in a dilute one. This is the same as saying that so far as the nitrate particles in such a solution are concerned, there is a water shortage. The situation might also be put this way: since nitrogen goes into the plant's roots as nitrate (NO_3), and only arm in arm, as it were, with just [83] so much water, obviously, if the water is crowded out by too many other things in the solution the nitrate particles will not get sufficient opportunity to enter the plant. On a beach, for example, overcrowded with many different kinds of people, the individuals of one particular kind will have much less opportunity to enjoy bathing freely and liesurely than they would have if the beach were half-deserted.

The practical consequence of this crowded condition of a concentrated solution is that one may have plenty of nitrogen in it, yet have the plant growing in it starve for lack of nitrogen. One is reminded of the "Ancient Mariner," who found that there was "Water, water everywhere, but not a drop to drink." This is one reason why the total concentration is kept well within the limits mentioned earlier.

The effect on the plant is to create an internal condition precisely like that discussed in the last section. In the event that the sunlight is normal, and the concentration is too high, more sugar will be formed than can be used up by the little nitrogen getting into the plant. Therefore, little protein will be made, growth will be slowed down, and the excess sugar will be turned into starch or into cell walls and wood. On cloudy days, such a concentration would be beneficial, since the amount of sugar produced would also be small, thus tending to balance the small intake of nitrogen. In that event, one would expect protein and cell-wall production to proceed apace.

4. PRACTICAL USES MADE OF HIGH CONCENTRATION. In transplanting young plants, it is desirable to harden them first. Some growers do this by means of increased concentrations. Suppose the concentration is raised gradually on bright sunny days, while more sugar is being formed. Since relatively less nitrogen is entering the plant, the excess sugar is used by the plant to make extra heavy cell walls; and, [84] what is more important, sturdy, woody conducting-vessels which will stand the plant in good stead during its later life. Such plants are less easily injured, and are less subject to disease.

Mr. Turner, one of the leading growers of roses hydroponically, makes a very clever use of this method of hardening. It is very easy to oversupply roses with nitrogen. By keeping the ppm of nitrogen relatively low (between 50 and 100 ppm) and fixing the potassium also at around 100 ppm, he secures enough nitrogen to produce the protein necessary for growth. Then, by lessening the water in the solution through increasing the total concentration, he gradually hardens his plants. Since there is not enough nitrogen for making both protein and cell walls, and there is more sugar available than required to make the small amount of protein from the nitrogen available, he accomplishes his purpose nicely.

5. SUCCULENCE IN VEGETABLES. Now let us see what might be done to produce succulent vegetables, in so far as this is due to providing a plant with nitrogen.

In the springtime there is not as much light as in the summertime. Therefore there is not as much sugar made in the spring as in the summer. Part of the sugar is used to make cell walls and woody vessels for conducting materials through the plant; part is burned in the process of making protein for the growing parts. If the nitrogen supply is regulated to keep a little ahead of the sugar being made, either by putting more nitrogen into the solution or by lowering the concentration slightly, there will be less tendency to have woody plants; and a greater tendency toward succulence. But if the concentration is allowed to become excessive, or if the nitrogen level in a more dilute solution is allowed to become low, then there will be a sugar-rich [85] condition inside the plant with consequent lack of succulence or tenderness in the vegetable.

There are only two ways to determine what is happening. One is to make chemical tests of both the plant structures and the nutrient solution frequently. The other is to gain skill by practice in observing the plant grow. The first is possibly only for those equipped to test. Most people have to rely on their experience. Since this book is intended for those who are unskilled in testing techniques, nothing will be mentioned on that point.

However, if repetition is allowable on so important a subject, obviously, to produce succulence in vegetables the nitrogen must be added to the solution with considerable care, as the daily amount of light increases. It should also be obvious that he who applies a formula blindly, rather than by use of his head, must either fail completely or have undeserved, but transitory success.

Incidentally, plants grown in greenhouses or in partial shade are sometimes more tender, for a longer period, than when grown outside. This is because in partial shade less sugar is made; and there is less danger of having an excess which might be turned into wood. Or, putting it the other way around, there is less likelihood of having a deficiency of nitrogen, and an excess of sugar.

In midsummer, the formation of sugar increases very rapidly, due to the long light periods. But high temperatures enter the picture also. If the temperature is moderate and the nights are relatively cool, the problem is simply one of adding nitrate in increasingly larger amounts without getting an excess, thus producing again a nitrogen-rich, sugar-poor plant. Also, one must avoid, of course, increasing the total concentration above the limits mentioned earlier. This problem is solved nicely by[86] changing the formula so as to give the added extra nitrogen desired without increasing the total concentration. Here is where a study of the tables given in Chapter 5 is helpful.

Actually, in so far as my own technique of feeding is concerned, there is little possibility of having an over-concentrated solution in hot weather. For the chemicals are added daily, and dilution by water is made at the time of feeding, by allowing water to enter the feeding tank before it flows out into the plant tank. Thus the concentration of solution at the plant's roots is always less than that indicated by the formula. Since the feeding tanks are filled to mark each night, and the process repeated daily, the plants get a specific amount of food daily and all the water they need. Over-concentration is avoided over a long drought, by spraying the sand surface with water.

6. HIGH TEMPERATURE. When the temperature hovers in the high nineties and over the 100 mark for long periods, and the light is intense for long stretches during the day, there arise disturbances inside the plant which may not be controlled. In fact, not all of them are known. Everyone knows that it is difficult to grow some kinds of plants in midsummer, when the temperature is excessively high. People in the desert are particularly aware of this. Here is a partial explanation. First, up to a certain point, absorption increases with temperature. Second, sugar tends to be produced faster than it can be used. Third, the respiration rate also increases with temperature rise, up to a certain point. The situation inside the plant really becomes complicated; too complicated to attempt an explanation here. Sometimes it happens that there is not enough sugar present to satisfy the respiration demands. That is when the plant starts to burn itself up.

Now then, suppose you[87] feed your plant too much NH_4. This will be used to make protein at once. But, since there is a shortage of sugar, the demand for new cell-wall material will not be satisfied. Thus the plant will seem to thrive a short while, then wilt and die. However, if you fed it NO_3, what would happen? If the oxygen supply were low the NO_3 would accumulate, and the plant would use up its body supply of oxygen. If the respiratory oxygen were sufficient some of the nitrogen would be turned into protein, and thus prevent the accumulation of NO_3. So long as there is sufficient sugar to take care of the burning process required to use up the NO_3, the plants will do well. However, this can't happen if the roots don't supply the oxygen.

7. FRUIT AND NITROGEN. Although excessive feeding of nitrogen retards or prevents fruiting, nevertheless, it is necessary to supply this element during the fruiting period. There is more to be desired in a plant than succulence and flowers. These things we like in a salad or a bouquet. But we wish, also, to have such things as beans and tomatoes. These are fruits. Before they may be formed nitrogen comes into the picture. Therefore, nitrogen must not be allowed to fall too low in the feeding schedule when the fruiting period is on.

8. SUMMARY OF NITROGEN. If the above discussion has been tedious, it is also important. Many more things might have been said had space been available. It was intended to emphasize the fact that giving nitrogen to a plant is rather difficult, if the best results are desired; particularly if one wants people to eat what he grows. The reader is urged to master the few details given. The genuine student will seek a fuller account in a standard text on plant physiology.

What has been said may be summed up under the following brief statements:

a. Nitrogen is used to[88] make the living part of the plant.

b. It is taken in either as nitrate (NO_3) or ammonia (NH_4).

c. It requires energy to turn the nitrate or ammonia into protein. This energy is secured through burning sugar, which is made only when there is light.

d. Since the amount of sugar varies, the amount of nitrogen given a plant must also vary. Otherwise we encounter either high-sugar and low-nitrogen plants, or just the opposite. Both are undesirable.

e. A high-sugar and low-nitrogen plant is produced when the concentration is excessive, or when absorbed nitrogen is not used because of low oxygen supply or high temperature. The result is that sugar tends to collect as starch or as woody hard parts; or the plant stops growing because not enough protein is made for the required protoplasm. A low-sugar and high-nitrogen plant is produced if the nitrogen is supplied too rapidly in the ammonia form when there is cloudy weather and little sunlight, or if there is a respiration upset because of prolonged high temperature. The result is that the sugar is burned almost immediately to provide the turning of nitrogen into protein, leaving none for normal cell-wall formation. The water balance inside the plant is upset, the plant continues to grow, but is too succulent, wilts, is susceptible to disease, and produces little or no fruit.

f. The amount of nitrogen given a plant is increased as the amount of daily sunshine increases, and decreased as the light decreases.

g. A plant may starve for lack of nitrogen even though its roots are supplied with much of it. This may be due to too high concentration of the solution.[89]

h. Best fruiting results are obtained with a moderate and well-balanced nitrogen feeding.

It should be obvious by now that there can be no such thing as a perfect formula, in the sense that all ingredients may be made into a cake and applied to all plants everywhere, in all seasons, under all conditions of weather, with amazing success in each instance. However, there are "merchants" of "plant food" who advertise this error as truth.

In introducing the other elements as they concern the problem of making up a formula, we must necessarily be brief. Some of them are varied as to amounts of feeding, but none so much so as in the case of nitrogen.

B. POTASSIUM. This element is used in the making of buds, leaves, root tips, sugar, starch and proteins, though it does not enter into the structure of some of these things. It provides a sort of "kick-off" to cell division. If it is not present, and in proper amounts, particularly in the early stages of growth, the plant cannot do a number of important things. Its deficiency is marked in various ways. In a tomato, for example, the lower leaves will turn grayish-green and the margins become yellow. This yellowing eventually spreads inward, the areas become brown and finally die. In a cucumber the same thing occurs, but here one notices also a bronzing effect, while the stem end of the cucumber fruit remains much smaller than the opposite end, which is the opposite of what occurs when nitrogen is deficient in this plant. A potassium-deficient radish is said to have knobby roots, with thick and leathery leaves, a characteristic some claim also for other plants.

Potassium is absorbed readily, except when there is an excess of calcium present. Thus there may be the proper amount of potassium in the solution but because there is too much calcium present the plant will be starving for it.[90] In such a case, the usual potassium-deficiency symptoms would show up unexpectedly.

The minimum amount required is about 70 ppm. But most formulas keep it around 150 ppm. Turner finds that this may be raised to as high as 1000 ppm. during winter and cloudy weather, or to offset excessive absorption of either nitrogen or calcium in certain cases for a limited time. The practical effect is one of hardening what would otherwise become a too-soft fruit, as in tomatoes, and of preventing the yellowing and withering of the lower leaves which have absorbed an excessive amount of nitrogen.

Another practical bit of information about this element is that it keeps the sugar moving from the place where it is made to the place where it is used or stored. It is thus clear that a plant like a potato requires a great deal of it, since the sugar made in the leaves is transported through the entire length of the plant down into the ground, where it is turned, presumably with the help of potassium, into starch. This is the principle substance stored in that underground stem familiarly known as a "spud," or in foreign countries, potato, or pomme de terre, according to the language.

C. PHOSPHORUS. This element actually becomes a part of the living material called protoplasm. Here again is an element which serves several purposes, making it thereby the more essential to a plant's life. Sugar is converted into the insoluble form, called starch, very quickly after it is made. In that form it is quite useless. It must be put back again into the soluble form. Phosphorus seems to be necessary in this turning-back process from starch to sugar. Since seeds are essentially infant plants lying dormant inside a wrapping of oil, protein or starch ladened tissues, it is not surprising[91] that phosphorus must be supplied to the plant particularly when it is fruiting.

If the absorption of potassium is interfered with by too much calcium, the absorption of phosphorus is interfered with by too much iron. In fact, iron and phosphorus have a mutual dislike for each other. One precipitates the other out of solution the moment its concentration is high enough to get the upper hand of the other. By keeping them both down near the minimum ppm permissible for good growth, this particular battle of the elements becomes less disturbing. By keeping the solution a little more acid than one would ordinarily, both seem to forget their chemical feud and enter the plant roots eagerly, thereafter doing what the plant expects them to do.

Incidentally, this battle of the elements is fought continuously also in a garden. In a hydroponicum we can keep it under control much more easily than in a garden or a field.

If the plant fails to get a sufficient amount of phosphorus, the deficiency shows up in stunted growth (a feature of most kinds of deficiencies), purple veins or even complete purpling on the under-side of the leaves, slender stems, and fruit that fails to set or mature. Even the roots fail to develop, a feature difficult to observe without destroying the plant. I have noticed that these symptoms are particularly noticeable in early spring when the temperature and light are low. The plants invariably come out of it when conditions are more favorable. This observation assumes that there are no apparent reasons for phosphorus shortage, through failure to keep the *p*H and iron-phosphorus balance reasonably correct.

The minimum concentration of phosphorus is 10 ppm, and it is generally unwise to allow it to exceed 100 ppm. A rose plant, for example, does well with 10 to 30 ppm, while a tomato, which forms fruit, would[92] require 60 or more ppm of this element, particularly during its flowering and fruiting period.

D. CALCIUM. This is the element which makes lime so important. Lime has been put on soil in one way or another for the past 5000 years, with little idea of why. Were words water, truly there would have been a deluge because of the prolonged debates over the use of lime. And the debate has not ended with the birth of hydroponics. Opinion among plant physiologists permits the concentration of calcium to range anywhere between 80 and 3000 ppm! Calcium is a very important element in the life of a plant. But, in general, such a high concentration of calcium would never be wisely attempted by the beginner.

By some, calcium is ranked higher in importance than is phosphorus. I prefer to consider one essential element as important as another. However, some are more difficult to handle than others, which makes them important to the operator of a hydroponicum. What makes calcium so important is the fact that it is used by the plant for several processes. For example, it neutralizes acids produced inside the plant. When a large amount of nitrogen is used by the plant a large amount of acid is produced. Since the plant has no excretory system, the only way it overcomes this acid accumulation is to neutralize it into some harmless substance. Thus calcium is used in a great amount for this purpose.

Several elements, among them magnesium, are harmful, if used in large amounts. In some way calcium helps reduce this harmful effect. Sodium, which is not used by the plant but which gets into it through the roots, harms the plant less if there is sufficient calcium present.[93]

Calcium deficiency is therefore not simply a matter concerning this element alone, but is connected with toxic effects produced by other elements when there is not enough calcium to offset them.

You may recognize calcium shortage by the fact that the growing point stops developing, and dies; also, the upper leaves turn yellow while the lower remain green. If the plant is removed, the roots will be brown and poorly developed.

One tries to balance calcium with potassium. If one uses a calcium concentration of 120 ppm, the potassium would be raised to 200 ppm. These figures are not to be considered precise. The point is that for general purposes one keeps the amount of calcium between the concentrations for nitrogen and potassium. Which means that the potassium is generally kept higher than either the calcium or nitrogen. When the nitrogen is low, say at 50 ppm, the calcium would be at least 80 ppm, and the potassium at least 150 ppm. On dark cloudy days, for prolonged periods, the potassium might be raised to as high as 500 ppm. But suppose the nitrogen feeding is very high, as in summer. Then the calcium would be raised also to perhaps 400 ppm, while the potassium would be lowered to around 100 ppm. It must be remembered that these suggestions are intended as a help rather than as a set of rules to be followed blindly. Simply remember that calcium and potassium are another pair of elements which tend to interfere with each other, making it necessary for the operator to be on his guard in giving them to the plant.

If the beginner follows the formulas given, he will in all likelihood have no difficulties regarding calcium. The only conditions which he should clear up are those in which the water used is already high in calcium. In that event none at all or very little should be put into the nutrient solution. Or the sand used may be high[94] in calcium. If this is so, it must first be treated with treble superphosphate in water, until the *pH* or acidity becomes stabilized at about 6.5. By this means the sand (or gravel) is coated with insoluble phosphate, and from then on the phosphorus in the solution will not be made insoluble by the excess calcium. If you don't do this, you will have to use more and more phosphate, or your plants will show phosphorus shortage, and you will have difficulty keeping the plant bed from becoming alkaline. Adding more acid will not relieve the situation if a calcium-high aggregate is the cause.

The minimum ppm for calcium is probably 80. There are some who feel that it should be placed at 120 ppm. Probably the latter figure is the safer.

E. MAGNESIUM. Just as your blood will not be red unless there is iron to form the nucleus of the hemoglobin particle, so will plants not be green unless there is magnesium to form the heart of the chlorophyll particle. Chlorophyll makes the great majority of life on earth possible. Without it, you and I could not possibly exist, since we, like all other animals, depend on it to provide us with food. Without it there is no food. Thus the importance of magnesium also. For without magnesium no chlorophyll is possible.

The most obvious consequence of magnesium deficiency would be a yellowing of the older leaves between the veins, just as in potassium deficiency, except that there is no bronzing effect as in potassium deficiency. Also the leaves tend to curl upward. An excess of it, on the other hand, tends to increase the total concentration and to cause hardening. It has been reported that an excess of this element causes the tops of plants to wilt in hot humid weather. Minimum amount is around 10 ppm.

F. SULPHUR. This element[95] becomes a part of some proteins. It also imparts flavor to some plants and aids in making chlorophyll. Leguminous plants use it for making their root nodules. A shortage of it is not likely. If so, the plants turn pale green and show tardy fruit formation. The minimum is around 10 ppm.

G. IRON. This element is used in three main ways. First, it assists in making chlorophyll, though it does not become a part of it. Thus the first sign of iron deficiency is a yellowing of the leaves, particularly the young ones. You may determine this very quickly by pouring a solution of iron citrate or iron sulphate over the sand (see formulas for the proper concentration). The plants will begin to turn green again within a few hours!

Second, it helps the plant to burn its manufactured food, thus providing heat energy for use in various processes. You may recall that sugar is burned when protein is made. Thus an iron deficiency interferes with this important process also.

Third, the living material itself, protoplasm, without which nothing happens inside a plant, has iron as a structural part of it.

Thus it seems that the plant really needs quite a bit of this element continuously. But it is rather difficult to get it served up on an acceptable platter, as it were. First, it will be recalled, an excess of phosphorus will not permit its absorption. Also, if the hydrogen ion becomes high, *p*H 7.0 or more, so that the solution becomes even slightly alkaline, it is not soluble, and is therefore not absorbed. Then, too, the concentration, if more than 10 ppm, is likely to interfere with phosphorus absorption, and, if the solution is very acid, so much of it will be absorbed as to become toxic, the roots being killed.

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Another element, manganese, when too high in concentration interferes with iron absorption. Thus, iron deficiency may be the consequence of a number of things.

The practical point to be remembered is that if one feeds his plants iron regularly, but in small amounts, he will have little or no difficulty.

The minimal amount required is probably about one ppm. If one could always be sure that none of it is precipitated out of solution, feeding as little as 0.05 ppm would be sufficient. So long as the phosphorus concentration does not go high (some growers keep it at around 10 ppm), or the alkalinity side of the *p*H scale is avoided, little trouble will be experienced with iron absorption and thus iron deficiency.

H. MANGANESE. This is another element that serves to help out in several processes as a sort of activator. There is reason to believe that whatever concentration of iron is used the amount of manganese should be just half that amount. Thus, if one ppm of iron is used, then 0.5 ppm of manganese should be used. This means that the toxicity of iron is due in part to a shortage of manganese, if the manganese is lower than the relative amount stated, and iron deficiency would result if the manganese is relatively higher than the amount given as desirable. Putting it another way, the absolute amount of iron is of less importance than the relative amount of manganese used with it.

I. BORON. At the New Jersey Experiment Station work is being done to show how boron feeding is related to calcium feeding. Perhaps boron is associated with the plant's use of the other major elements. Whatever the use of it, and however other elements may later be proven to be associated with it in normal plant processes, it is known that all plants need it.

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Great care must be exercised in using it. First, because it is more toxic to some plants than to others. For example, corn will not tolerate it to the amount that cauliflower and beans will. Second, because, as in the case of several other elements, its chances of harming the plant depend upon the relative amounts of other elements, particularly the other trace elements.

A shortage of boron causes different effects in different plants. In general, the growing tip of the plant first shows browning, and soon dies. The leaf stalks and veins become extremely brittle. The leaves have a tendency to burn at the tips, to become malformed and twisted, particularly the young ones. But the reader should be reminded that leaves twist for other reasons also. The margins eventually become brown and have a burned-up appearance. In strawberry this is very pronounced.

The minimal amount varies between one ppm and 0.01 ppm, according to the kinds of plants grown, the amounts of other elements present, and the condition of the nutrient-solution.

For practical purposes, using a concentration of 0.2 ppm, regularly causes neither a deficiency nor an excess.

Nothing need be said about copper, zinc and molybdenum, the remaining trace elements, except that they are very toxic in even low concentrations. It is probably best to use them in concentrations not more than 0.01 ppm, and then only infrequently.

Now that we know what elements to use, and something of what use the plant makes of them, as well as some of the consequences of their excessive use or of their deficiencies, let us next examine the formulas which have actually been used and published. None of them can be used without

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some changes being made as the season progresses, as the plant matures, and to satisfy specific needs of different species of plants. But they do serve as safe guides. And the earnest beginner will soon learn by experience how to make the required changes as they arise. Indeed, every time a change is made, one has a new formula. But for practical purposes the plants will tolerate a great deal of misuse of formulas, provided the required amount of aeration is kept up and the acidity or *p*H is properly maintained. When these go wrong, no formula is worth its salt.

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CHART 2. FORMULAS

Chemical used	% Purity	Weights in grams to be used in making up 1,000 liters of solution. For one barrel, divide by 5.								
(READ DOWN in all columns)		I*	II	III	IV	V	VI	VII	VIII	IX
Potassium nitrate, KNO_3	95	1100	286	536	949	1100	1100	440w 1100s		
Calcium nitrate, $Ca(NO_3)_2$	90	190	30w 256s		774		540	540		
Monocalcium phosphate, $Ca(H_2PO_4)_2$	99	216	40	254	127	155		254	254	254
Magnesium sulphate, $MgSO_4$ (double if Epsom salts is used)	52	139	54	260	455	85	260	260	260	260
Ammonium nitrate, NH_4NO_3	95								0w 62s 228s	0w 82s 228s
Ammonium phosphate, $NH_4H_2PO_4$	85						300			
Ammonium sulphate, $(NH_4)_2SO_4$	94			119	113	140				
Calcium sulphate, $CaSO_4.2H_2O$ (gypsum)	85			1286		760				
Hydrogen sulphate (sulphuric acid), H_2SO_4	conc.									294
Hydrogen nitrate, HNO_3 (nitric acid)	conc.								378	
Sodium nitrate, $NaNO_3$	97								540	650
Potassium chloride, KCl	95								560	720
Calcium oxide, CaO (lime)	90								186	186

Note: Formulas I to VI inclusive modified from originals published in literature cited. All reduced to similar purity of chemical used, and to grams per 1,000 liters. Otherwise unchanged. Any errors in calculation noted must be charged against the present writer. *From "Complete Guide to Soilless Gardening" by W. F. Gericke, published by Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, New York, at $2.00. Copyright 1940 by Prentice-Hall, Inc.

w = winter.
s = spring and summer.

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CHAPTER 7
Formulas

We come at last to answering the "sixty-four-dollar question": "What formula do you use?" Here are given nine different formulas for you to try. They are put into one chart, Chart 2, and given a Roman numeral for identification. The people responsible for them are identified in the paragraphs which follow.

Formula I. This is the formula developed by Gericke. It is used for growing both flowers and vegetables. See his text for detailed directions on the technique used and the manner in which the trace elements are added.

Formula II. Mr. Wayne I. Turner, of Kankakee, Illinois, kindly furnished this formula. It was developed for growing roses commercially in greenhouses, using the aggregate system. This formula is the result of many years of practical research. The roses grown prove its worth. I have seen the roses, and can vouch for the formula. Mr. Turner, who is one of the outstanding pioneers in growing roses commercially and who has spent much time and effort trying to induce others to adopt hydroponics, writes me that in his opinion "It is a practical, scientific, commercial venture for anyone."

Since this formula is the consequence of scientific acumen and commercial experience combined, such a statement by so high an authority would not be made without genuine confidence in the formula itself. If the reader consults the text written by Turner and Henry, he will discover that the formula has been changed considerably between 1939

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and the present. It is hoped that the authors will soon revise their text, and include the details which brought this formula to its present form.

Interestingly enough, the only trace elements used with this formula are iron and copper, the latter probably unnecessary, in the opinion of Mr. Turner.

Formula III. This is also a rose formula, or, better still, a flower formula. It is the famous WP formula developed by Arnold Wagner and G. H. Poesch at the Ohio Agricultural Experiment Station, and, I assume, under the direction of Professor Alex Laurie. The recent paper by Kipplinger and Laurie indicates that this formula has been tested over so long a period and covers so many questions as to the use of different substances used in the gravel or aggregate technique that it should be placed high on the list of successful formulas.

It is used either in ½WP, WP, or 2WP concentrations. The reader must consult the book by Laurie or the papers listed, for details. In general, the ½WP concentration is used during the early life of a plant, and the other concentrations follow in order, as the season progresses.

Formula IV. If one visits the New Jersey Experiment Station at New Brunswick, he will see roses growing with the use of this formula. It was developed under the direction of Dr. O. Wesley Davidson, and is to be found in its original form in a paper by him published in the July 1946 issue of *Soil Science*.

Having seen the roses growing in this solution in mid summer, I again vouch for a good formula. The reader may be surprised to find that roses may be grown equally well in solutions which vary greatly in concentration, as seen when comparing this formula with that of Turner. Professor[102] Davidson very wisely points out that "The concentration and balance of nutrients in the solution surrounding plant roots in artificial cultures vary more or less, depending upon the rate of application of the solution, or, in the case of solution cultures, upon the amount of circulation. This is particularly true of the nutrient substrata surrounding the roots of plants in gravel cultures. It is apparent, therefore, that the choice of one nutrient solution over another one varying from it slightly with respect to the concentrations of various major nutrients present is unwarranted. This statement is not intended to minimize the importance of the balance of ions in a nutrient solution. The point to be emphasized, however, is that such a balance is concerned with a suitable range of concentrations of various major nutrients rather than with the strict maintenance of given concentrations of each.

"This contention does not apply to the minor elements, or micronutrients, since small differences in the levels at which they are provided in nutrient solutions are known to effect pronounced changes in plant growth."

The reader may feel that so lengthy a quotation from so scientific a paper in a book of this sort is out of place. But let us see. Dr. Davidson has put his finger squarely on a point that has not only interest for the scientific investigators but also the commercial grower. The point is this: For a formula to be satisfactory, you don't have to insist on trying to keep the concentration of each major element in it at a given level. This means that you may choose any formula you wish, regardless of how it differs from another, so long as you choose one which has been developed on correct principles. It does not mean that you can put just any old thing into a solution and expect a good crop. Mark what Davidson says in the first sentence quoted, and be impressed[103] with the idea that the conditions under which a formula is used is also significant. There is no one in a better position to offer this advice to a beginner than is Professor Davidson.

Formula V. Here we attempt to bring in the work of the staff at the Purdue University Agricultural Experiment Station. The formula given here is one of many developed under the direction of Dr. Robert Withrow, who designed one type of growing tank used in the Gravel System, and who, together with his wife, Dr. Alice Withrow, plant physiologist, developed the formulas published in the army manual on hydroponics.

This is the now famous 2D formula, an honor which it shares with the 2E formula developed by the Purdue group. In recent years a number of new formulas were developed on the lines of these two, and for meeting specific demands during the recent war. I regret that I am not at liberty to report these here, through no fault, I am happy to say, of Dr. and Mrs. Withrow, who have been most generous with their information.

Formula VI. This is a tomato formula developed by Arnon and Hoagland, and was taken from the Davidson paper cited above. Since I have no first-hand information regarding it, the reader must consult the paper by these authors for details on how it is used.

At this point a word is necessary regarding the use of micronutrients. These have not been given with the above formulas because the authors use them differently, according to the technique of using the nutrient solution as a whole, and to the manner of mixing the trace elements themselves. They differ also in the frequency with which the trace elements are added. Space does not permit giving all these details here. Besides, most of the details may be secured[101] in the articles and books, especially the latter, listed in the bibliography section of this volume.

Formula VII. This is the original formula developed by the author and used up until the last war. A word should be said regarding its origin.

Since the entire objective of my own efforts in hydroponics was to develop a system devoid of mechanical devices and which could be operated with a technique that did not require much skill in testing, it was clear that the formulas developed for other systems might have to be modified because of a difference in the number of times the solution would be supplied to the plants, as well as the difference in the amount of flow or circulation which might be attained.

Since, also, the light intensity varies greatly in the Conway region through the growing season, an attempt was made to apply the potassium-nitrogen relationship suggested by Turner and Henry. The plants grown were tomatoes, beans, corn, lettuce and beets. The results were satisfactory in all cases. The chief difficulty encountered was an overfeeding of nitrogen to tomatoes, which resulted in the browning and drying-up of the lower leaves, when plants were grown in the greenhouse. This difficulty was not encountered when plants were grown in the outside hydroponica.

Formula VIII. This formula is the consequence of two unfortunate situations. First, the last war cut off the purchase of calcium nitrate and potassium nitrate. Second, there came a severe storm which blew down the building in which my chemicals were stored, filling the storage jars with water and debris. Since there was no possibility of getting a new supply, and to waste the diluted material would have been criminal, the only thing to do was to dip it out in a No. 1 tin can, and guess at the concentrations. The surprising result was that the crops were grown to maturity without

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serious difficulty. As a consequence of these two disasters, sodium nitrate, potassium chloride, lime and nitric acid were substituted for the two unavailable chemicals.

For winter use, extra potassium could be supplied by using extra amounts of potassium chloride, without serious trouble from free chlorine. For summer use, a third chemical, ammonium nitrate, was added to provide the extra nitrogen required as the season progressed. By increasing this salt gradually, and avoiding its use entirely on dark cloudy days, very satisfactory results were obtained with tomatoes particularly. One unit grown on this formula produced 746 pounds of marketable tomatoes between April 1 and July 12, 1947. It would appear that the formula is satisfactory for tomatoes when grown in a region where the daylight periods are long and the temperature, during the growing period, varies between 40 and 100 degrees F.—when used, of course, with the particular form of hydroponicum and technique described elsewhere in this book.

Formula IX. This is essentially the same as number VIII. In it sulphuric acid is substituted for nitric acid, and the potassium level is raised, while the nitrogen level is lowered. Thus, this formula may be used in winter and for starting plants, and Formula VIII substituted for it as increased nitrogen is required.

It should be noted here that there is a limit to supplying extra nitrogen through the use of ammonium nitrate. The maximum given in the two formulas is considered to be within safe limits. If more nitrogen is desired than provided by either of the last two formulas doubling the amount of lime and acid should meet requirements, or use calcium nitrate instead of lime and acid, as in Formula VII, would be satisfactory.

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It is understood that people are frightened at the sight of tables and charts. But it is hoped that the reader will examine carefully the following Chart 3. It shows how the nine formulas vary in the concentration of the various major elements. Note that the potassium level is generally a little higher than the nitrogen, and that the calcium level is consistently kept below the nitrogen level. Compare this with

CHART 3. *Ppm of each essential element in each formula*

	I	II	III	IV	V	VI	VII	VIII	IX
Nitrogen	168	50w 100s	100	250	168	252	140w 224s	168w 284s	98w 210s
Potassium	390	100	214	300	390	390	156w 390s	234	351
Calcium	80	33w 101s	320	192	184	120	160	160	160
Phosphorus	62	10	62	31	37	62	62	62	62
Magnesium	24	10	48	84	12	48	48	48	48
Sulphur	32	13	320	137	160	64	64	64	64

w = winter or early spring.
s = summer, long days of sunlight.

the situation in Chart 4, where the formulas are compared on the basis of the relative number of absorbable particles, rather than on the basis of the concentrations of the elements in them.

CHART 4. *Relative numbers of absorbable particles (ions) in the formulas*

Ions	I	II	III	IV	V	VI	VII	VIII	IX
Nitrate, NO_3	12	3.6w 6.8s	5.5	16.5	10	10	10w 16s	12w 16s	7w 11s
Ammonia, NH_4			1.6	1.6	2	2		0w 4s	0w 1s
Potassium, K	10	2.6	5.5	7.7	10	10	4w 10s	7	9
Calcium, Ca	2	1.2w 2.2s	7.2	4.8	4.6	3	4	4	4
Phosphate (H_2PO_4)	2	0.3	2.2	1.0	1.6	2	2	2	2
Magnesium, Mg	1	0.4	2.0	3.5	0.5	2	2	2	2
Sulphate, SO_4	1	0.4	8.9	4.3	5.5	2	2	2	5

w = winter or early spring.
s = summer.

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Charts 3 and 4 are included here, not to complicate matters by a lot of technical details, but to furnish you with a sort of guide for making changes in any formula you use, if for some valid reason you deem it to be necessary. That you may understand Chart 4 a little better, let us explain it by the use of Formula VI. For every two particles of ammonia available for absorption by the plant there are 10 particles each of nitrate and K, 3 of calcium, and 2 each of the others.

Now let us note a few things. In Chart 3 the ppm of potassium is higher than the ppm of nitrogen, in all but Formula II. But in Chart 4 is revealed the fact that there are more nitrogen-bearing ions available for absorption than there are of potassium. This is because the plant uses much more nitrogen than potassium during its lifetime. In Formulas VII, VIII and IX the difference between the number of nitrogen-bearing particles and those of potassium is greater because these formulas were used in a region where there is very much sunlight.

Note also that those who use the ammonia particle (or ion) for nitrogen use it sparingly. This is because, as noted earlier in this book, the plant uses the ammonia nitrogen for making protein, while it uses the nitrate nitrogen for making both protein and cell walls. Thus if too much ammonia is used, the plant will tend to be flabby or oversucculent. It is also apparent that an attempt has been made in each formula to keep the various particles somewhat balanced against each other. This happens to be a very important matter, but entirely too technical for consumption by the average reader. It is enough, perhaps, to say that no one has yet succeeded in balancing ions perfectly, but that what balancing has been done is most important, and has been considered in making the various formulas presented. In another decade or two, you will read books

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giving formulas much improved in this respect. Since these formulas work, it is probably safe to say that plants are not as much interested in parts per million and in grams as they are in the way one contrives to give them a balanced diet of ions.

Use of Trace Elements

Trace elements may not be varied as to ppm as much as may the major elements. Plants suffer from a lack of them, and may be ruined by an overdose of them. The amounts given below in Chart 5 are considered safe. Directions for using them with my particular type of hydroponicum and technique are given below.

One writer has said that plants show a deficiency trouble only when they have not had any of a particular trace element. That could scarcely be said to hold either for iron or manganese. I go on the assumption that it is safest to give plants a little of each trace element frequently, taking precautions against overfeeding them.

One writer notes that food-grade chemicals have enough of zinc, copper and molybdenum in them that adding any of these is generally not necessary. Turner writes that he has never observed signs of copper deficiency in his hydroponicum, though he uses copper very, very sparingly for no particular reason. I have found the same to be true with regard to all the trace elements with the exception of iron, in the Conway area, and with the kinds of chemicals I use.

Another writer observes that the amount of manganese used should be just half the ppm of iron used. He seems to feel that if one has added, let us say, twice as much iron as the plant can use, the toxic effect can be countered at once by adding manganese. In my own experience I have found evidence of iron deficiency in tomatoes after growing for

some time in a unit which had been sterilized with potassium permanganate. Taking a tip from the above suggestion I argued that the plants were not suffering from iron deficiency so much as from manganese excess. The plants were then given a watering of iron citrate solution, and recovered in four hours. This appears to support the idea that keeping the two in proper balance is more important than the absolute ppm of either iron or manganese.

On the other hand, still other writers point out that if too much manganese is offered the plant, this element has the effect of inducing the plant to take up more calcium than is good for it. Thus, since calcium in excess interferes with iron absorption, we have a sort of merry-go-round situation: Give the plant too much manganese, it speeds up calcium absorption. When this gets too high, there is an iron shortage. Add more iron to relieve the shortage, not only does the plant fail to absorb it but the iron now begins to interfere with phosphorus absorption because of increased concentration. Please do not try to figure all this out. It is unnecessary. But it should warn you that the part of wisdom demands care in the use of the micronutrient.

Boron is another element that may not be used without caution. Some plants like beans and cauliflower use much more than corn. Thus, if you had these plants growing in the same unit and fed them enough boron to satisfy the beans, the corn would suffer toxic effects. It would take several books to review all the possible mistakes which might be made with trace elements. I think I shall end these remarks by saying that, in general, you will have little or no trouble with trace-element deficiency if you use food-grade chemicals, and, once in a while, add a pound of commercial rock fertilizer mixture such as is used for ordinary gardening. I think that much too much has been written about defi-

ciencies, so far as practical hydroponics is concerned. The only exception to this statement would be those regarding iron.

With these remarks in mind, now turn to Chart 5, and the directions given below for the use of trace elements.

Chart 5. *Trace elements—amounts and how to use.*
Weights given for 1,000 liters, or 1,000,000 grams, or five 50-gallon barrels.

Trace element desired	*Its chemical source (see Table II)*	*Ppm used*	*Weight required*
			(grams)
Iron	Ferric ammonium citrate or ferrous sulphate	1.0	5.00
Manganese	Manganese chloride or manganese sulphate	0.5	1.80
Boron	Boric acid or borax	0.5	2.80
Zinc	Zinc sulphate	0.05	0.25
Copper	Copper sulphate (blue vitriol)	0.02	0.10
Molybdenum	Molybdic acid	0.01	0.02

DIRECTIONS FOR USING (not including iron):

1. Make the nutrient solution the proper acidity (*p*H) before adding.

2. Weigh out accurately ONE-FIFTH of each amount given in chart, for the chemicals selected. Use these as SAMPLES. Keep in very small containers for reference. Small glass vials are good. These are the amounts for ONE BARREL of nutrient solution. NO LUMPS.

3. Use a similar measure (vial) for determining amounts to be used. This avoids weighing repeatedly, and is accurate enough, provided extreme care in judging the volume of material is taken.

4. As an alternative to direction 3, make a stock solution as follows: (a) Weigh out 20 times amounts given in chart. (b) Dissolve in slightly acid water ONE GALLON (stock solution). (c) Use 1 cc. per quart, 4 cc. per gallon, or 200 cc. per barrel of nutrient solution ONCE A WEEK, if solution is used repeatedly.

5. If nutrient solution is renewed daily, USE ONLY 25 cc. PER BARREL DAILY, from the stock solution.

6. If nutrient solution is renewed daily, and direction 2 is followed, USE ONLY TWICE A WEEK.

DIRECTIONS FOR IRON:

7. Dissolve amount given in direction 2 (ONE-FIFTH) in acid water, if ferrous sulphate is used. Use dry if ferric ammonium citrate is used.

8. Add to nutrient tank just before feeding, stirring it up—TWICE A WEEK.

9. In case of iron deficiency (yellowing of top leaves) either use daily or water the bed with iron solution by means of sprinkling can.

CHAPTER 8

How to Use the Chemical Tables in

Making or Changing Formulas

I. The Direct Method

This is a technical chapter. It should not be read by the beginner until after he has practiced hydroponics a while, and wishes to gain some information on how to do the arithmetic involved in determining exactly how much of a given chemical is required to produce the given number of ppm asked for. So far as the beginner is concerned, all such calculations have been made for him. Table II tells exactly how much of a given chemical is required to yield one ppm of any essential element, for any chemical listed. This is a mighty handy table.

For example, if you should happen to know (see Chart 3) that a certain formula calls for 100 ppm of nitrogen, you may turn to column one, Table II, and find that you have seven different chemicals (including grades) furnishing nitrogen. In the last column of the same table you would find that it takes only 285 grams of ammonium nitrate, while it takes 643 grams of calcium nitrate to yield the 100 ppm desired. So it goes with the other five listed. But, if you happen to choose calcium nitrate, how would you know how much calcium was included with the nitrogen? Let us see.

By dropping down the table to the calcium group, and spotting the 90 percent calcium nitrate, you find that 4.50 grams of it yield one ppm of calcium (column 3). Obviously, 112 then, one gram of it would yield 0.222 ppm ($1 \div 4.50$) of calcium. Thus, since we used 643 grams of this salt to get 100 ppm of nitrogen, we also got 643×0.222 or 143 ppm of calcium in the deal.

Now let us try it the other way, by finding the amount required to yield 143 ppm of calcium. There are six ppm columns already calculated for your convenience. Now, 143 is the same as $100 + 4 \times 10 + 2 + 1$. At the bottom of the ppm columns for 100, 10, 2, and 1, you will find the amounts of calcium nitrate required to yield the respective ppm. Thus, $450 + 180$ (4×45) $+ 9 + 4.5$ gives us a total of 644 grams. This is within one gram of what we determined in the previous paragraph. This is close enough agreement for all practical purposes.

II. The Millimole Method

Now let us do the same thing by another method. Many workers, for scientific reasons, use the relative weights (molecular weights) as the unit of concentration. By taking 180 grams (see Table I, column 2-B) of calcium nitrate and dissolving it in 1,000 liters (1,000,000 grams) of water, we have what is called a millimole concentration. In columns 4N and 4Ca of the same table we find, after calcium nitrate, 28 in the N column and 30 in the Ca column. This means that in one millimole (180 grams) of calcium nitrate there are 28 ppm of nitrogen and 40 ppm of calcium. In one millimole (200 grams) of the 70% calcium nitrate there would also be 28 ppm of nitrogen and 40 ppm of calcium.

Now then, how much calcium nitrate would you need to supply 100 ppm of nitrogen called for in our example above? This is very simple. Since 180 grams yield 28 ppm of nitrogen and we want to secure 100 ppm, then $100 \div 28$ tells us that we need 3.57 times 180 grams. This amounts to 113 643 grams, which is the same as we secured by the direct method.

As before, let us see, by the millimole method, how much calcium was secured in these 643 grams of calcium nitrate. Since we said above that 1 millimole (180 grams) of calcium nitrate contains 40 ppm of Ca, and since we had to use 3.57 millimoles to get the nitrogen required, evidently we also got in this deal 3.57 times 40 ppm of calcium, or 142.8 ppm. This again agrees with our calculation by the direct method.

The secret of this agreement is very simple also. The direct method depends upon the correctness of Table II. But, Table II had to be determined from Table I! If the calculations had not been made for you, you would have had to do that calculation yourself, if ever you came up against the problem of trying to decide just how much of a given chemical it takes to make one ppm of any element in it.

In the event that you ever have to add to Table II this is the rule to follow: Divide the molecular weight of the chemical by the weight of the element wanted, and point off properly. For example, if there are 28 ppm of N in 180 grams of calcium nitrate, then $180 \div 28$ gives 6.43 grams as the amount necessary to furnish one ppm of N, when dissolved in 1,000 liters of water, of course.

III. Selecting the Chemicals

Since we have a choice of several chemicals in making a formula to provide the required ppm of the various elements, what chemicals would serve best? The following rules are helpful:

A. It is more economical to use a chemical having two essential elements in it than one that has not. For that which the plant cannot use is a waste. It costs money to ship waste material.

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B. If a waste-containing element cannot be avoided, then use also a second chemical with a waste element in it and one that will combine with the first. For example, chlorine is a waste in potassium chloride, and sodium is a waste in sodium nitrate. We may use these together, because the sodium and chlorine unite to form relatively harmless sodium chloride, or table salt, which is easily washed out by rain.

C. Use the chemicals you can get, rather than insist on having precisely those called for in a formula. So long as you keep pretty close to the ppm called for, it matters little what chemical you use. But it certainly is unhandy to have to make such adjustments. For example, if you cannot get potassium nitrate but can get calcium nitrate, you would have to get your potassium from some other source. Perhaps you would have to get added nitrogen from some other source also. For, by adding more and more calcium nitrate to increase nitrogen you would soon get more calcium than would be safe. You could solve both difficulties by using potassium chloride and sodium nitrate.

D. Use as few chemicals as possible under the circumstances.

E. In an emergency, if you happen to lack a specific element in the chemicals on hand, such things as wood ashes may be used to supply some potassium and calcium. You would have to use acid, of course, to make the *p*H correct. I sometimes keep these covered with water in a galvanized tub or bucket. This dissolves zinc, and some copper from the tub. A cupful of this added to a full tank of nutrient-solution, once in a while, furnishes these elements in sufficient quantity. I have never yet noted poisoning from this source. This should be done, however, not more than once a month. The reader will think of other things which may be done in an emergency.

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IV. Procedure in Determining Weights

Suppose that you know how many ppm of each major element are prescribed in a given formula, but do not know how much of each chemical containing them should be weighed out. After all, sooner or later one has to transform parts per million into weights. Let us illustrate the solution of this problem by an example.

We shall select Formula IX for use in this explanation. See text, Charts 2 and 3.

The ppm called for each essential element (Chart 2) are: Nitrogen (w), 98; potassium, 351; calcium, 160; phosphorus, 62; magnesium, 48; sulphur, 64.

Let us assume that we have the following chemicals available: potassium nitrate, calcium nitrate, monocalcium phosphate, magnesium sulphate (Epsom salts), potassium chloride, nitrate of soda (sodium nitrate), lime, nitric acid and sulphuric acid. You see, we have gotten hold of quite a number of chemicals in advance, simply because we wished to prepare ourselves for an emergency. We know, for instance, that the little potassium nitrate we have was hard to get. The next time we order it, we may not be successful. Therefore, we have very wisely taken advantage of an opportunity, and bought up a small supply of potassium chloride and sodium nitrate when we had the chance.

But we are not going to use all these chemicals simply because we happen to have them. We shall follow the rule of using as few as possible, to supply the essential elements in the concentrations called for.

Potassium nitrate gives us two essential elements—potassium and nitrogen. Calcium nitrate supplies another, calcium, as well as extra nitrogen. Monocalcium phosphate provides the necessary phosphorus, with some calcium.

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Epsom salts has in it what it takes to supply sulphur and magnesium. Four chemicals are all we will need, provided we can succeed in weighing them out in proportionate amounts. That is, provided we do not get too many ppm of one element while getting the right amount of another. It is a sort of trial and error affair. But, since you are new at this, I will give you the trial without the error, to save confusion.

Rule one: If a chemical contains two essential elements, satisfy the formula by use of the heavier of the two, first. This will leave a small balance of the lighter element to be supplied by another chemical. On this basis we choose potassium nitrate, since it contains both potassium (the heavier) and nitrogen (the lighter).

We need 351 ppm of K. Table I shows that it takes 110 grams of potassium nitrate to provide 39 ppm of K. Thus, 351 ppm $\div$ 39 tells us that it will require 9×110 grams to supply 351 ppm of K. In other words, we have used 9 millimoles. But for each millimole, we also got 14 ppm of nitrogen. Thus, 14×9, or 126 ppm, is the amount of nitrogen we also have.

Obviously, we are in a jam. We only want 98 ppm of nitrogen. If we use only 7 millimoles, 7×14 will give us exactly the 98 ppm of nitrogen we need, but only 273 of K (7×39). Here is where a little head work comes in. For my own part, I would look over Chart 3, to find that Formulas II and III both use less potassium than Formula IX calls for. One of these, Formula II, is for growing roses, and the other, Formula III, is celebrated as a flower formula. But, since you insist on growing tomatoes, and Formula VI was developed by an authority for tomatoes, it would be wise, perhaps, to approach the solution of the problem by substituting potassium chloride and sodium nitrate for potassium nitrate. This upsets our desire to use

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as few chemicals as possible, and to avoid waste, but sometimes it is necessary to make a compromise. Let us then make the substitute. But let me add this. In all probability you could go ahead with the reduced amount of potassium without much difficulty. However, don't make such reductions unless you are in a mood for experimentation and are willing to take the consequences.

Thus we make a second start. It is certain that we will have to decide the potassium amount first, since potassium chloride is our final choice of chemicals. By the same method used before, since one millimole (80 grams, Table I) of potassium chloride yields 39 ppm of K, it will require 9 (351 ÷ 39) millimoles to yield 351 ppm. This amounts to 720 (80 grams × 9) grams. But this leaves us with some chlorine waste. How shall we get rid of that? Well, it so happens that when a millimole of potassium chloride (80 grams) is put with a millimole of sodium nitrate (90 grams, see Table I), the chlorine and sodium unite. But in doing this how much nitrogen did we secure for our formula? Since one millimole (90 grams) yields 14 ppm of nitrogen, then 9 millimoles of sodium nitrate yields 9 × 14, or 126 ppm of nitrogen. Again we have too much of this element. Again we are in a jam. If, however, we use only 7 millimoles, 7 × 14 gives us exactly 98 ppm of nitrogen, the amount desired. But this allows extra chlorine, since only 7 millimoles of the 9 of potassium chloride used were neutralized by the 7 of sodium chloride. These few extra particles of free chlorine will in all probability find some stray hydrogen partners, and hook up with them to form hydrochloric acid. If this happens, the tendency for a solution to go alkaline about the roots will be counteracted somewhat. On the other hand, if they remain free they will either evaporate into the air or tie up with some dead material not wanted anyway.[118]

Thus we settle on 7 millimoles of sodium nitrate instead of 9, and weigh out 7 × 90, or 630 grams.

We now come to the problem of solving the calcium requirement. This is tied in with the phosphorus needs, since they both occur in monocalcium phosphate. Table I shows that one millimole (254 grams) of this chemical furnishes exactly what we want for phosphorus (62 ppm). This amount carries with it, also, 40 ppm of calcium. Subtracting 40 from 160 ppm, the calcium requirement, there remains 120 ppm of calcium to be supplied. We cannot get this from calcium nitrate without increasing our nitrogen. We can get it from lime (CaO), by adding enough sulphuric acid to neutralize its alkaline effect. Table I shows that 62 grams of 90 percent lime will yield 40 ppm of calcium. Therefore, if we use 3 millimoles of it (120 ÷ 40, the ppm wanted, divided by the ppm in one millimole) it will require 62 grams × 3, or 186 grams of lime to provide the remaining calcium required. Likewise, since it takes one millimole of sulphuric acid (98 grams of concentrated) to neutralize one millimole of lime, it would take 98 grams × 3, or 294 grams. (Note: You would have to use 2 millimoles if nitric acid were used).

This leaves only magnesium and sulphur to be supplied. One millimole of Epsom salts (260 grams) yields 24 ppm of magnesium and 32 ppm of sulphur. Thus, 2 millimoles yield 48 ppm and 64 ppm respectively, and the job of calculating is complete for the major elements of formula IX, for the ppm required.

V. Checking for Other Factors

A. TOTAL CONCENTRATION. It was stated earlier in the text that the total concentration of salts in a solution should be kept between 500 and 3,000 ppm, as a rule. Adding up[119] the final weights determined in the last section above, we find that the total concentration is 2,170 ppm. Referring to Chart 3, and adding up the total ppm of the various essential elements, it is found that their total is only 993 ppm. This is less than for some other formulas, and more than for others. Thus, the choice of chemicals seems to be satisfactory from this point of view.

At this point a common confusion should be cleared up. It will be recalled that we have been talking of making up 1,000 liters of solution, whereas in the description of the Unit System we refer to one barrel or 250 liters as the solution unit. The 1,000 liters are used for calculation, since this has been adopted by plant physiologists as the most desirable dilution when a molecular weight of a given chemical is dissolved in it. In other words, it is the millimole that is adopted as the unit for calculation. One may use, however, any multiple or fraction of it, to secure the ppm desired. The confusion in question is this: If 2,170 grams of total salts are used to make up 1,000 liters, and we use one-fifth this amount or 434 grams to make up one 50-gallon barrel (one-fifth of 1,000 liters), will not the ppm for each element also be but one-fifth that calculated? The answer is that the ppm for each element will remain relatively the same. This holds also for the total concentration. Although you use only 434 grams to a barrel of water, you still have a concentration of 2,170 ppm total salts in the barrel. This is because you kept the relative amount of water equal to the relative amount of chemical salts used. *But*, if you diluted the solution to two barrels, after once making it up, the total concentration would be one-half that given. And if you doubled the amount of salts weighed out for one barrel, and put that into one barrel of water, then the concentration would be doubled.[120]

B. CHOICE FOR SPECIAL REASONS Table I lists a number of chemicals in which desirable elements are tied up with sulphur. Such chemicals are often cheaper than others, and an excess of sulphur ordinarily does no harm. But I have found that in regions where the temperature is excessively high, and with the use of my own system, sulphur bacteria have a chance to thrive, producing not only obnoxious gasses but toxic to the plants. I have never found this with the formulas I have used. But others, who tried to use commercial fertilizers, at the suggestion of a fertilizer agent, had serious difficulty. It has always been my practice to use a minimal amount of sulphur because, quite by accident, I found that onions, radishes and lettuce grown this way seemed to have less bitterness or sting to them than those grown in the garden. Icicle radishes, in particular, were not at all "hot." I now know the reason. Dr. Davidson reports, in a personal communication, they discovered at the New Jersey Experiment Station that it is excessive sulphur which appears to be the culprit in producing "hot" radishes. It is thus apparent that the beginner has much to learn about securing best results, besides having a formula and a satisfactory method for applying it.

VI. How to Handle Variations in Purity

Throughout this discussion we have intentionally used food-grade chemicals, of the percent specified in Table I. But what would you do if the chemical you bought were of different purity? This is very likely to happen. If the purity is only a few percent lower or higher than those given, you may make a rough guess by weighing out a little more or less, and let it go at that. But if you made a mistake of 25 percent, in magnesium, or phosphorus, and perhaps nitrogen, there are times of the year or periods

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in the plant's life when this would be harmful. It is better to make proper calculations for corrections in purity.

All you have to do is correct column 2-B in Table I. Follow this rule: Multiply the molecular weight (column 2-A) by 100, and divide by the percent purity of the chemical you have bought. Don't forget, however, that by thus changing the amount you actually weigh out, through this correction, the ppm of the essential elements remains the same as for the pure chemical.

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CHAPTER 9

Where to Buy Needed Supplies

I. Chemicals

As noted in a previous chapter, the chemical and fertilizer industries have not yet organized their sales departments to supply the needs of the hydroponicum operator. This is due to the fact that not enough hydroponica are in operation to warrant their doing so. It is therefore necessary to warn the reader that he may not be able to secure his chemicals from the sources listed, although the writer has no reason for believing that his requests will be ignored.

The Monsanto Chemical Company furnishes the *monocalcium phosphate* in several grades. The purest grade is 99 percent. The branch offices of this company are located at St. Louis, Missouri; Akron, Cleveland, and Cincinnati, Ohio; Mobile, Alabama; Houston, Texas. It is possible to send this chemical to foreign countries, through their foreign trade service.

Calcium nitrate and *potassium nitrate* may be purchased in 200-pound barrels from the J. T. Baker Chemical Company, Phillipsburg, New Jersey. Specify food grade.

As a substitute for calcium nitrate, one may use lime and nitric acid. I have done this since the supply of calcium nitrate was cut off. It is handier to use calcium nitrate, and it may be a little cheaper. But if one buys the nitric acid in quantity sufficient to supply the needs for one year, it is possible that this and the lime combination would be more economical. Certainly, lime may be had anywhere,

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and nitric acid is easily secured through any chemical house. Technical grade is the kind to buy. In using lime one should make sure that the magnesium in it is not too high, or at least take this into consideration in feeding magnesium sulphate.

W. H. Curtin and Company, P. O. Box 118, Houston 1, Texas, and Greene Bros., Inc., 1812 Griffin St., Dallas 2, Texas, will supply the trace elements. These companies are distributors, not manufacturers, of chemicals. Their quotations must therefore be a little higher for the bulk chemicals than one would expect to get from the manufacturers, since the latter sell in large lots. You will find these companies ready to give very favorable quotations on 100-pound lots, for the bulk chemicals.

Calcium sulphate, or *gypsum*, is supposed to be easily secured through local fertilizer merchants in the United States. I have not found this to be true except in limited areas. I have been informed by Mr. L. L. Coleman of the Brown-Miller Pickle Co., Texarkana, Arkansas, that the United States Gypsum Company, 300 West Adams St., Chicago, Illinois, will supply information of the shipping points for this product, upon request. They have plants at Sweetwater, Texas, and Gypsum, Ohio, among others.

Sodium nitrate (Chile), potassium chloride (muriate of of potash) and *ammonium nitrate* may be secured through local fertilizer merchants. However, the supply of these is not yet certain. The Arkansas Fertilizer Company, Little Rock, Arkansas, is in a position to supply these chemicals.

Magnesium sulphate, as Epsom salts, may be secured from any drug company. McKesson and Robbins, Inc., Chicago, Illinois, and the Baugh and Sons Company, of Baltimore, Maryland, are two companies suggested.

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above, sell another type, which should be satisfactory. It is just as satisfactory to use any type available. The reader may contact any chemist in his neighborhood, and secure information regarding the use of such testing papers. Litmus paper will not do. The kind to use is one that will register the *p*H between 4.0 and 8.0.

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The F. W. Berk and Co., Inc., New York City, used to handle potassium nitrate, under the trade name of Potnit.

ILLUSTRATION 5. A group of five fruits on an eggplant.

It is possible that they are now in a position, since the war, to continue this service.

All in all, the distribution of fertilizer and chemical manufacturing centers has changed so much during and since the war that it is difficult to find them. The reader may uncover sources near his home, through the local Chamber of Commerce, in many instances.

The Hydroponics Distributors, Inc., P. O. Box 191, Little Rock, Arkansas, is being organized to contact manufacturers of those chemicals used in hydroponica, and to serve as distributor to operators in the United States. This will be of inestimable value to small as well as large operators, since they will be in a position to have their needs supplied in a single order. It should save considerable shipping and time loss. Fertilizer companies furnishing suitable fertilizers for hydroponica will find an outlet for their product through this same channel.

The Dow Chemical Company, Midland, Michigan, furnishes *magnesium sulphate*.

Armour and Company, Chicago, Illinois, supplies *ammonium sulphate* and *potassium sulphate*. Branch offices throughout the world.

II. Special Apparatus

Only two pieces of special apparatus are required to operate the Spessard unit type of hydroponicum. These are a glass graduate, which any druggist will supply, and an acid indicator. I use at the present the Alk-Acid Tester, sold by the Fischer Scientfic Co., of Pittsburg, Pennsylvania, and St. Louis, Missouri. Greene Brothers, Inc., mentioned

CHAPTER 10

Growing For Home-Use and Profit

Under the above caption we will consider the economic aspects of the garden crop as a whole. To grow plants profitably the operator of a hydroponicum must not only succeed in raising a crop but he must also dispose of it. Disposing of it requires in turn that he crop it carefully, grade it, clean it, transport it, have a ready buyer, a satisfied consumer, and a profit. What is required to grow the crop was covered in Chapter 6. But planning when and what to grow, in order that a profit may be had, is something many a gardener and farmer cannot figure out. So will it be with those who approach carelessly this business of hydroponics.

Then there is also the problem of costs; financial support in beginning such an enterprise. Since these are encountered first, let us take them up first.

I. Construction and Operational Costs

I think that the best way to introduce this topic is to give an example from my own experience. My present plant consists of five full UNITS (see Chapter 5 for definition) comprising 1,000 square feet of growing area. These UNITS cost anywhere from $18 to $70 each. The difference is due to the fact that two of them I poured myself and took advantage of opportunities for buying materials cheaply, while three were contracted for. When the latter is done the contractor's profit, labor, and materials com-

bine to make the cost high. This will of course vary similarly from place to place. There is little to go on for comparing costs of constructing tanks for the various systems used, except to say that it costs approximately twice as much to construct a V-bottom tank used in the highly mechanized systems as it does to construct the flat-bottomed tanks used in the others.

The operation costs for running the hydroponicum proper for the 1,000 square feet, from April 1st to July 15th, were:

Measuring out and mixing the chemicals, 8 hrs.	\$ 8.00
Opening and closing drain nipples, 8 hrs.	8.00
190 lbs. of chemicals	15.20
12,500 gallons of water	5.00

Filling tanks is done while other things are being done, such as pruning, taking a meal or tying up tomatoes. These are not chargeable to hydroponics cost. If the operator himself will count his profits as his own labor cost, labor being considered an item when it must be bought, the \$16 would be deducted from the above. If the operator is investing money only, and expects to have the hydroponicum operated by hired labor, the \$16 would of course be included as overhead.

To make the illustration complete, this particular crop of tomatoes sold for \$318 on the local market. In other words, the hydroponicum itself was paid for by one crop of tomatoes. This same area can be used to raise at least two other crops in one year, with outside growing weather. One of the units, operated the previous year for a full season and which cost \$38 to construct, netted two crops of tomatoes and one crop of beans, \$116 for the 200 square feet. This year, the same unit netted \$120 for a single crop.

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The first cost—the construction cost—of a UNIT is, let us say, on the average, \$55. That area has the productive equivalent of 12 areas of ordinary garden space. Each year the garden has to be plowed, or spaded, and repeatedly worked until planting time, perhaps several times, and kept constantly cultivated, weeded and mulched. If all this heavy work of turning soil is considered for one growing season only, and summed up as labor of the hardest kind, it is found that it costs no more to build a UNIT which is good for a hundred years, than to do this hard work for one year. But the telling point is this: In the UNIT, you are sure of a crop. In the garden, the drought or high water may make your labor a loss.

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ILLUSTRATION 7. A section of one unit showing the first clusters of tomatoes, the type of wire supports with loops suspended from the wooden frames above. Other units may be seen in the background. The tomatoes were about half grown. Photograph by Mr. Ray Bruce.

ILLUSTRATION 8. Showing the adjustable type of drain-nipple leading from the drain-channel and out through the wall of the greenhouse in which the hydroponicum was located. This adjustable feature to the Spessard-type of hydroponicum was added by Dr. Charles Deevers, who made the photograph.

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11. FINANCING FOR THE SMALL OPERATOR

If we go on the principle that one should not double his UNIT until he has first learned to operate it, so that it pays for itself in one year of full operation; and if, on the contrary, he is not afraid to double it after he has achieved this success; and if he will refuse to double it after his hydroponicum gets large enough to give him a satisfactory income, or is not producing at the desired point of efficiency, then he may in confidence ask for financial support from his local banker. This would require that he first have ambition, skill, and money enough to build his first UNIT himself and settle down to the task of learning how to operate it. He need not concern himself about high cost of chemicals, if he has to buy them in small quantities during this learning period. Since during this period his one objective is to raise a crop successfully, and determine what crops are profitable in his region. Any banker knows that the larger the operation the better are the opportunities for economical buying. It costs 35 cents for a pound of Epsom salts, if you buy it one place, and 3 cents if you buy it at another, for example. Chemicals are bought generally in 100-pound lots at least, even when operating no more than a thousand square feet.

III. A Successful Way for Securing a Dealer

I operate on the principle, in so far as marketing is concerned, that there are three people concerned in this sort of transaction who must be mutually satisfied to consider the deal complete. Otherwise it is not business, but a racket. Let us illustrate the point by use of a tomato crop.

The three people concerned with a tomato are the man who produces it, the merchant who sells it, and the person who eats it. If the man cannot make a respectable

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living producing it he is a loss to the others, for he will either quit, or complain about the unfairness of the other two. If the one that sells it cannot make a profit, or if he takes a loss, he cannot stay in business. Thus the grower and consumer are both out of luck. If the one who buys it finds he has purchased a faulty fruit, having neither taste, nor satisfactory appearance, in short has not his money's worth, he feels that he has been cheated, will complain, and go elsewhere to buy. Thus both the marketer and the producer are out of luck. It is strange how stupid people are about such a simple matter. But, since they are, the successful tomato grower will first produce a tomato that tastes well, looks well, that the merchant is happy to sell, and the consumer will buy in preference to other tomatoes, even perhaps at a higher price. People will do this if they feel that they are getting their money's worth. Since he is growing for local consumption the operator does not have to consider shipping qualities of a tomato. He can concentrate on taste and appearance.

This is the arrangement I make with my merchant. I agree to sell him tomatoes or other produce in first class condition on two conditions: first, that he suffers no loss because of poor sales or of poor fruit. I take that loss up by not delivering him more than he can sell in one day, and by delivering only fruit that is salable. I am the one that watches the market, not he. The merchant is therefore guaranteed a 20 percent profit on every dollar of my goods sold, and is not obliged to buy a dollar's worth. The other condition is that I set the price at which the goods are sold. This price is governed by the local market, plus comparative values as between other types offered for sale, and the readiness with which the fruit moves. The merchant is at liberty to buy any other tomato on the wholesale market, but is required to furnish me with separate display space.

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In other words, the tomatoes are on their own. Experience shows that merchants are more than glad to cooperate on this basis. I have not dealt with chain stores, consequently know nothing of their response to this type of merchandising. It should not be necessary to add that I am particularly scrupulous in seeing that I keep my side of the bargain, that the merchant is to take no loss, and that the complaining customer must be given new fruit without questions asked, in case a defect is reported. In selling 1,500 pounds of tomatoes only one tomato was reported black inside, and only three pounds had to be taken back because of unsalability. This is probably a record in merchandising perishable fruit. It is this kind of merchandising that will knock out the waste which is now so enormous. In fact, it is this waste tax which the hydroponicum operator is in position to collect. No other producer is in that position.

On this basis, if we assume that one man could not operate more than one hydroponicum acre of tomatoes himself, he would have to prepare a set of merchant customers who would be able to absorb approximately 80 bushels of tomatoes daily for a period of 10 days, and from one to 50 bushels a day for two weeks before and after the high producing point. A town of 7,000 people will have about 15 stores handling fresh tomatoes. Most of these could not sell more than one bushel a day, for eating purposes, when the market is high. The largest store would not sell more than 10 bushels. Consequently, either the price would have to be cut or a market would have to be sought elsewhere, or both, if the crop is not to be a loss. In other words, the operator must be a merchant who knows his market saturation point, when it will in all likelihood hit him, and be prepared beforehand to meet it.

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Retail merchants and growers have for a long time been the victims of what is known as the middleman difficulty. The consumer is likely to jump to the conclusion that the middleman is responsible for the high cost of food as well as its inferior quality. The farmer also complains that the middleman promises one thing, and does another. This leaves the poor middleman in an embarrassing position. He must of course be expected to look out for his own interests. If he agrees to take up a carload of tomatoes at a certain price, and at the time the tomatoes are delivered the car expected is two days away on a railroad siding, either he has to refuse the tomatoes or take a loss. Naturally, he will refuse the tomatoes. Thus the producer is left holding the bag. This sort of condition has characterized merchandising, since the writer helped ship a car of peaches as a boy, only to discover that in the transaction a widow was left holding the bag. It is therefore not without a reason that he has sought for a way to eliminate this wasteful condition which satisfies no one. The evil lies not with people

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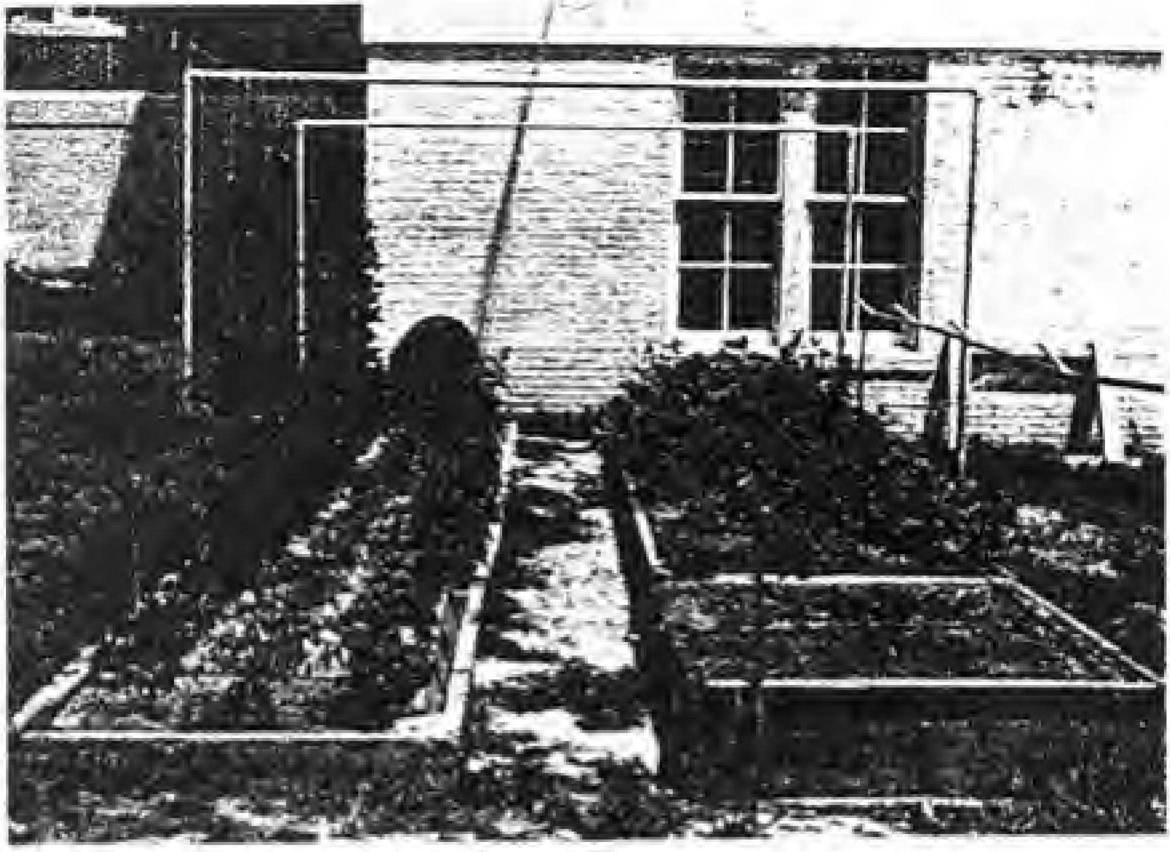

ILLUSTRATION P. A view of Dr. Charles Deevers' Hydroponicum, located at Mississippi College. The unit on the left is the Spessord-type; that on the right, the Gericke type of hydroponicum. Photograph by Dr. Charles Deevers.

so much as with the system. Once we succeed in producing perishable food at the point where it is consumed, all over the world, the vicious system of present merchandising waste will disappear, and there will be more profit at the production end. This is not theory. It is the report of an actual performance which may and must be duplicated in every small and large town in the world.

IV. The Family Hydroponicum

To be really practical, a hydroponicum should be of the sort that can be readily adapted to the production of food for a family. In the last section it was urged that growing a garden is actually more expensive, the way gardening is done now, than operating a hydroponicum. The difference may be stated succinctly. The old way of garden-

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ing is done in sweaty overalls; the new is done in clean lounging clothes. The old confirms the barbaric belief that sweat and toil are necessary virtues to true happiness; the new subscribes to the gentlemen's philosophy that unnecessary sweat and toil are an aesthetic abomination.

All of us are gentlemen at heart. Now is the time to be one, in the home hydroponic garden.

A. SIZE REQUIRED. If the family is small (not more than three persons) the tin-can method (see Chapter 6, Sec. IV) may be used to advantage. The initial cost is low, there being no other expense involved than that for providing paint to cover the cans, and the chemicals. The chemicals, if the bulk ones are bought in 100-pound bags, will cost around $25, but will last several years for a small hydroponicum of cans.

If the family wishes to can carrots, beets, corn, tomatoes and the like, for winter use, a larger hydroponicum would be necessary, and a UNIT or more should be constructed. To be conservative, you may count on 200 square feet of tank space (actual growing space) as equal to at least 1,600 square feet of garden space; and may, according to locality and skill, be made to equal 2,400 square feet of garden space in productivity.

B. CROP PLANS FOR UNIT. The only examples I can give are from my own hyproponic garden in a locality where three crops on the same UNIT are certain during the period from March to December (some things being kept in the sand bed over winter), and where five crops, when accurately timed and spaced, are possible. The examples follow:

A certain UNIT, let us call it No. B, had tomatoes, with flower buds showing, transplanted to it April 1st. It

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went through two light frosts, the support frame being covered with newspapers. The crop was 570 pounds of tomatoes of useful grade. The UNIT was cleared and sterilized July 3rd, washed July 4th, and replanted in giant Lima beans, July 5th. This crop lasted until November 13th, and yielded 58 gallons of beans in the hull. Onion sets were planted deep in the sand on November 14th, and were mulched with compost for winter, after coming up. Some were used up during the months of December and

January, during the time the sand was not frozen. In February, a second set of onions were planted in between the cross rows of those already beginning to turn green again. By the middle of March these were coming through the sand, and the winter crop was ready to sell. The second crop of onions was out of the sand on April 12th, when the UNIT was again sterilized, and tomatoes with flower buds showing or open were planted in it April 15th, after frost danger had passed. The onion crops yielded a little over 5,000 spring onions, with five-inch-long tender and sweet bodies. Thus this UNIT, as planned, grew one crop of tomatoes, one crop of Lima beans, and two crops of onions, in a 12-month period.

On another UNIT, by beginning in September, two crops of onions were raised over the autumn-winter period, a third in the spring, tomatoes in early summer, and Kentucky Wonder beans after these, making a five-crop rotation in one year on the same UNIT. These examples should be sufficient to indicate the possibilities.

Those who live in regions where to get one crop is all that is to be expected, because of limited temperature and light, will of course not be interested in rotation, but in growing several things at the same time, in the one UNIT. The following suggestions may be helpful. Any good book[138] on gardening will give information on what grows best with what. This is not a peculiarity of the hydroponicum but is inherent in the plant's nature.

Tomatoes may be grown in the same UNIT as used for potatoes, but the potatoes should be planted near the surface of the sand and covered with straw or leaf mulch and kept moist, so that the potatoes will form under this rather than in the sand proper. Or, sand may be heaped up around the potato stems, and held in place by a wooden frame set on the sand.

Corn and eggplant do not grow well together. Celery is a special crop, requiring less phosphorus than tomatoes and more calcium, potassium and nitrogen. The *pH* for tomatoes and most other crops should be around 6.5 or lower, while that of celery would be above this. Thus celery will not do well with other plants. It will go to seed. In general, you may plant the following in the family hydroponicum: Cabbage, beans, peas, lettuce, carrots, tomatoes, beets, cauliflower, onions, potatoes, sweet corn, and strawberries, if you are in the colder regions. In the warmer regions, where growing plants separately is more easily done, because not all of the vegetables need to come in at the same time, okra, black-eyed peas, peanuts, eggplant, butterbeans and melons may be added to the list.

In all cases, of course, care must be taken that no plant shades another. Some will do better than others, when grown together, but the objective being to feed a family rather than to produce bumper crops, one must be satisfied with this limitation if only one UNIT is available. Experience alone, as in a garden of ordinary type, teaches one the really fine points of individual preferences in food by different plants.

Perhaps it should be[139] emphasized[140] once more that some plants simply will not thrive in extremely hot weather over a prolonged period. Only experience will tell you what these are. Although much sunlight is needed for good growth, when that becomes too intense, and the temperature reaches the high nineties or goes over the 100 mark, efficiency on the part of the plant stops, and in some cases drops too low for its survival. The reasons are too technical for discussing here; but knowing this is of practical importance. For it is little use to attempt to grow plants under conditions too far removed from those naturally

ILLUSTRATION 10. Another view of the bean crop shown in Illustration 2, showing in addition a portion of one feeding-tank which is placed between two 25-foot growing-units. In the foreground, one of these is seen planted in cauliflower. The temperature at the time the photograph was taken, was 110 degrees F. Neither the beans nor the cauliflower had gone through a rain. Photograph by Dr. Charles Deevers.

required by the plant. There is a limit, in other words, to what a plant may be expected to do.

It may be of interest to know that growing "roasting ears" in the home hydroponicum will make them cost around five cents apiece. But that is about what one has to pay for them at the store. In the frozen package they cost around 15 cents each. However, one who has once tasted a hydroponically grown ear of corn, after it has been shucked and cooked immediately in boiling water for seven minutes and no more, will be willing to grow his corn thereafter that way, even if he has to pay 25 cents a pound for his chemicals. This is admittedly comparing the incomparable.

Finally, if it is cost that bothers you, sell yourself your produce at retail prices, since that is the way you have to buy, and you will find your hydroponicum a profit to you, at almost any level of prices.[141]

CHAPTER 11

The Tanks Are Coming

The first hydroponicum used by man was a broken fragment of coconut shell in which the juice of that fruit was fermented and sampled to the satisfaction of a primitive human palate. This may be stretching a point, since the microscopic yeast plants grown in this early form of nutrient solution were utilized incidentally, though they no doubt contained some vitamins of value.

If the first incentive to grow plants in solution was the irresponsible one of providing a jag, the last is inspired by fears of malnutrition, the high cost of living, the fear of famine, disgust with the present uncertainties and waste of food distribution, and intent on getting those elements essential to the maintenance of a sane and physically competent human race. For the first time in his history, man is genuinely concerned about the prospects for his survival as a species. And this concern derives as much from the world food situation as from concern over atomic warfare.

I. Present-Day Interest in Hydroponics

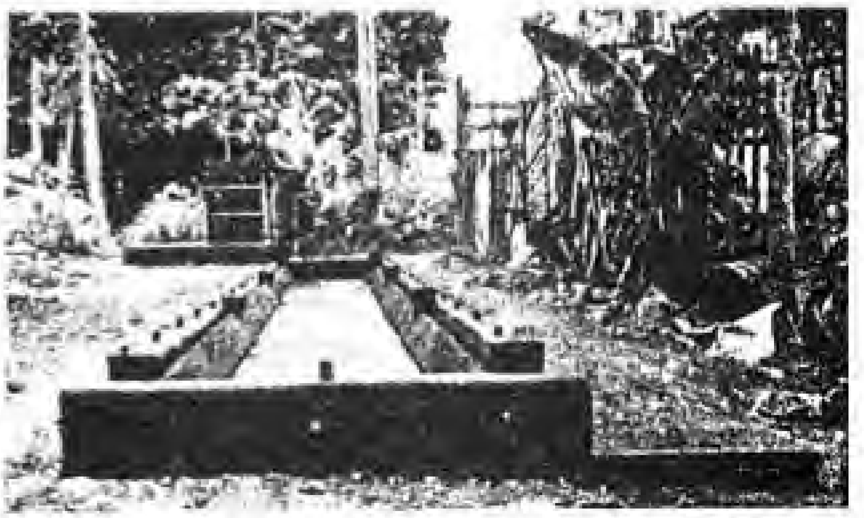
Among the many articles on hydroponics which have appeared in the press recently, three were responsible for bringing to my desk a flood of letters from all parts of the world. They are, in order of the articles published by their reporters, the *Log Cabin Democrat*, the *Arkansas Gazette*, and the *Magazine Digest*. A review of the interests expressed in those letters is impressive.[142]

The foremost interest is in improved nutrition,[143] both for the individual household and the world. "One loaf of bread," writes one, "and a can of condensed milk with fish-head stew for a variety, is our diet for a family of eight. I figure if I can learn this thing they call hydroponics, and I think I can if anyone can, we'll be eating better along this bayou."

Perhaps the following illustrates best the second point made: "Being farmers at heart, my brother and I are eager to take up hydroponics at our suburban home just outside the city of Damascus and, following your footsteps, get to something which might go really far, considering that hundreds here die of typhoid and almost 100 percent of the Middle East population suffer from some form of dysentery. Not counting those, who, like us, are absolutely fed up with choosing between that and a permanganate slow-poisoning diet . . . The world, Sir, is becoming smaller every day and it would be a perfect example of international cooperation if your scientific efforts could be used in faraway Arabia. It will take a lot of such efforts to make a better world."

The president of an air-lines company in Mexico looks to hydroponics as a means of providing his employes, from tropic to desert landing field, with better green food. An official invited to study the prospects for improving meat

ILLUSTRATION 11. The metal barrel feeding-unit of the "Apolo Spessard-Hydroponicum" at Rio de Janeiro, Brazil, in the course of construction, as modified and constructed by Mr. A. S. Jacobsen, the ingenious gentleman shown in the photograph. Special precautions were taken in this construction to avoid growing difficulties due



to insect and microbe pests. (Below) The "Apolo-Spessard-Hydroponico" ready for filling with sand. The solution, in this instance is introduced at the far end, and recovered in the sump shown in the right fore-ground. Photographed by Mr. Alfred Jacobsen.

and other food supplies for the people of Peru wonders if part of the solution of his problem is to be found in incorporating hydroponics into his general plan. In Brazil, Venezuela, Cebu and Nigeria the concern is the same as in Arabia. In Palestine and Australia the interest is in getting control of drought, the great enemy to crops. In Laborador, Canadian outposts, and cold regions where the growing seasons are short it is the desire to get away from the inevit-

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able tin-can meal that causes people to look upon hydroponics as a possible relief. In farming provinces of the far North it is hoped that by this means the canning industry may be made more profitable, and more people employed.

My answer to all such inquiries has been if proper care is taken in planning, and sufficient time consumed in mastering the rather simple details, there is little doubt that each and every one of these needs may be met satisfactorily through hydroponic methods of one sort or another. I believe this to be true, though it is also true that it will take time, good will, money and intelligence. Probably the best results will be accomplished without government aid, since to be successful the economic problems must be solved through accepted economic procedure. Money is not a consideration when a scientific problem is to be solved, or when a political situation must be faced. But if one is to eat out of his own hydroponicum, or buy food from another operator, that hydroponicum which cannot operate within the all-around monetary requirements from producer to consumer must become a disappointment, a white elephant, and a thing to stay away from.

This brings us to the second interest expressed in the letters, namely, that of growing vegetables and flowers for the market. This is inspired by the glowing reports which have been achieved by isolated individuals here and there. It is encouraging to note that there is not a single genuinely crack-pot letter out of the whole. The public is quite prepared to understand the inevitable exaggerations which appear. Only one individual expected to quit his job, turn his few acres immediately into tanks, apply the "perfect formula," allow the plants to fight off their own enemies, if not prune and crop themselves, and himself become rich the first season. When informed, of course,

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that formulas may be had for a dime a dozen, and that hydroponic perfection is not yet of the magnitude to be found only in paradise, the inquirer very sensibly gave up his premature ambitions.

If the letters represent a fair sample of public opinion, the public is definitely past the wild-eyed stage of hydroponics, and is prepared to look at the thing sensibly. People are not asking so frequently, "How much profit can I make out of it? How much does it cost?" But they are asking, "How do I go about learning how to grow plants this way?" There are two groups interested in hypdoponics from the commercial standpoint. One is the individual who wishes to build gradually in his home town, unit by unit as it pays for itself, until he has a good livelihood, and who expects to operate no more than he can handle himself. The other group consists of organizations interested in cooperating for marketing purposes, but having the individual operators work, plan and maintain their hydroponic establishments independently. In other words, it is the individual grower on his own as far as producing is concerned, but all united into a sort of union for pooling their information.

The latter groups are convinced that this can be done economically, or are at least inquiring if this is so, and that if so, believe that their community's basic wealth will, through adopting proper hydroponic methods, become gradually more stabilized than it is at present. By basic wealth they mean, I take it, individual and community health plus increased productivity of the local land area. The interest is primarily in permanent community building and against mutual community exploitation. It is as though these people have all read and hope to disprove the passage, "Each one strives against, not with, his brother. Thus each strikes a wretched bargain 'gainst himself, and knows it not."

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The third group consists of elderly and retired people. They are the people of the world who have met up with those years when to be able to work is joy. It is their dream, a dream that also is my own, that through this simple device, this little thing we call a growing-tank, the whole world might come more quickly into possession of its daily bread; that through it we who differ so much from land to land, yet are so much alike, might find a way to help each other even as we help ourselves; that there can be small fear of war once all peoples are well fed.

He who works now for long hours over his little hydroponicum in an "old people's home" sits no more in loneliness. I do not know how well he has succeeded, but he has now the most valuable thing on earth: something to do. It is significant that he should write again to ask, "Is it all right to let some of the others here grow things this way?"

A retired sea captain, writing from a ship as it enters a Caribbean port, insists that hydroponics is "just the thing to keep me from spending my days dreaming of the many ports I've visited, and wishing I were at sea again."

A man of 85 years, who rides a hot bus 300 miles to see for himself what all this is about, finds a new way to exercise his joy in learning. And he tucks his lessons under his arm, rides back home at once, saying before he leaves, "I was once known as 'Celery Jim' up North. I will make a go of this thing. I won't make anything out of it myself, but my grandson will. For I will teach him how."

These are the people who refuse to look backward.

Then we come upon that group of people wise in human weakness—doctors, men and women old enough to earn rest, and rich enough to quit; who, as one said, "never do quite get used to seeing people die"; and who look to
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their hydroponic garden as a place where they may for a few minutes each day, work out in the open with the lovely things of life, and forget. They have a million patients whom they wish to teach, after they have learned themselves, in order to keep those neurotics from having to spend hours on the couch of a psychiatrist.

It would be a bit impertinent to suggest that either of these groups is the more or less significant sector of the body politic. Together, they show that interest in hydroponics is worldwide. They represent significant portions of the world population. Their interests may therefore not be ignored.

But, although much publicity has been given hydroponics during the past two decades, a publicity which no doubt accounts in part for the present response, the most significant fact is that little of the vast amount of reliable information on hydroponics has been put into a form which may be consumed by the nontechnical public. The public is not stupid and is not moronic. But it is frightened at the sight of unnecessary technical verbiage. Also it is rather fed up on soft-coated hydroponic pills, and has become slightly disappointed and suspicious. Yet, in spite of this, we have the response recorded above. It was to help fill the gap between our technical achievements in hydroponics, and the common hope for using the scientific knowledge available, that this book was written.

ILLUSTRATION 12. A section of one unit showing cucumber vines growing as a second crop after harvesting tomatoes. The plants had just passed two weeks of weather when the temperature reached 105 degrees F. daily. The vines were not protected from the sun, and thus the leaves show some wilting at the time the picture was taken. This set of vines produced a fine crop of cucumbers during September and October.

II. The Hydroponics Future

This is not a prophecy. It is a plan. It is a plan in merest outline. To fill in the details, one man would be incompetent. The plan is based on the assumptions that the first step in making hydroponics generally useful has now been successfully taken, and that people the world over are ready to adopt hydroponics as a permanent method for growing much of their food.
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Hydroponics is here to stay. It has already been established as the sensible way to grow greenhouse produce. It has been adopted as a means for growing vegetables by the army, which is in a financial position to use the more mechanically refined techniques. Many individuals, either
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army-trained or having the technical background and financial backing, are at present engaged in hydroponics successfully. But all this is but a drop in the bucket. It remains to teach the interested public how to equip and operate a hydroponic home garden, and also those who wish to grow plants for the local market. It might take 200 years to bring hydroponics into general use, but it may be done much sooner if we plan intelligently. It would seem that, granting the assumptions stated above, what therefore remains to be done is essentially as follows:

First, hydroponic information must be gotten to the public through our regular channels, namely, the press, radio and the schools. Second, a liaison group must be trained to translate the technical details worked out in the experiment stations and plant physiology laboratories into the practical language of truck farmers and gardeners. Let it be emphasized at this point that the public cannot in reason insist that a research man be an investigator and at the same time what he is pleased to term "practical." The most practical thing that is ever done, I submit, is what the laboratory man is doing. But, it is true that someone must act as go-between for him and the final applicator of his work. In other words, it is not a question of what is or is not practical, but one of language. It is also a matter of efficiency. With this out of the way, let us go on.

Third, young couples, interested in founding a home in the suburbs or countryside, and at the same time intelligently interested in food production as a livelihood, must be given the same chance in training as we now give to the more orthodox phases of agricultural training. I am not at all prepared to endorse the idea of giving this training below the college level at the present stage of develop-
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ment. The course, as I see it, would include eight hours

of general botany, eight of general chemistry, eight of plant physiology, and sixteen of actual work with operating a hydroponicum. This latter would mean growing two crops through two seasons successfully, after constructing the hydroponicum itself. Four hours of economics, including principles of marketing and financing, would be added. This program of education would do two things for the individual: It would give him a tool for making a living, and leave him time enough to get a real fine arts education also, which in turn would be his equipment for living. To give this training to people of high school age would in all likelihood degenerate into a system of giving easy credits, probably the most pernicious disease of our American educational system.

Fourth, the building of hydroponic tanks must now be started by interested individuals first in the home garden; next in the home-town outskirts for truck farming to produce for those without a home hydroponicum; next, large-scale hydroponica, individually controlled and operated, but associated for large-scale marketing in near-by cosmopolitan areas, and within a few hours of hauling distance.

These four steps are intended secondarily as part of the food defense of a country in case of atomic war. It will be much more difficult to destroy an enemy's food supply if that food is grown in scattered areas and at the points of consumption. Even though the main transportation system of the nation be knocked out, people will be able to feed themselves from the local larder. It is not a question any more of national or individual finance. In an emergency such as atomic warfare, money saved will have much less nutritional value than a carrot in the hydroponicum. And in those places where the people are not killed it would be

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stupidity par excellence to be caught alive, and without one's own hydroponicum, after a bombing disaster. It is not my intention to be facetious at this point. I am not counting on the inevitability of atomic warfare. But, if such is the inevitable, then it is now time to prepare against it. And the hydroponicum is the cheapest instrument we have for this purpose. The distribution of hydroponica would be such as to extend the present limited growing areas into mountainous and desert regions. In Chapter 5 it was shown that if the annual rainfall is properly conserved in even the driest part of the globe a definite amount of food may be grown in those regions for supporting human life. This will undoubtedly be done.

The fifth and final step would be, of course, the conversion of farm and grazing areas into hydroponica. This must be a long time in coming. But if we intend to plan at all, we might as well make our plans worldwide, and with an eye to contributing to world peace by striking at the heart of one of the causes of world war. We forget, sometimes, that the human race has never yet had three square meals a day. People, like cows, must have a full stomach regularly, to long remain contented. And contentment is a consequence of great and successful planning.

We will turn our farms eventually into hydroponica for several reasons. First, we will thereby conserve our "fertilizer" supplies. The way we now use these is a waste tax which cannot be supported indefinitely. Second, our present plans for water conservation takes into account only the prevention of floods, loss of topsoil, maintenance of recreation areas, and the water supply to large industrial population centers. As a matter of fact, except in the desert areas, practically all of this controlled water becomes river and stream again without being metered out first for plant

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growth. This will be corrected, once we become hydroponically built up as a nation. Third, we will insist on having our chickens and cattle fed from hydroponically produced food on the spot, because this will be done more cheaply than is now done by our roundabout methods, and because the meat, milk and eggs will be thereby more nourishing. Fourth, we will go to hydroponic farming just to get out of hard labor. Man has desired, more than any one other thing, a way to avoid sheer toil and sweat. He can stand the tears, but too much hard work gets him. Hydroponic farming wipes out most of this.

Let us see the picture as it will look to the world after we have done those five things.

Food will be available all the time, everywhere.

Cattle and chickens will eat their forage from hydroponic mangers and feeding beds, the whole year around.

Harvesting of forage crops will be eliminated. The billion dollars spent now on machinery for harvesting, curing, baling, and hauling such feed will be spent to better purpose.

The attack on insect enemies and parisitic fungi will be planned differently, and will be more successful.

Plant physiology departments will become the bureaus of food production, and will provide the basic plans for distributing and feeding people, livestock and poultry in a unified program of food defense, either for peace or war. The people, of course, may choose what they will eat and, to a certain extent, where they will eat it. But the downright independent, through-and-through individualist in such matters, the one to whom cooperation and any semblance of coordination are intolerable, that one must be permitted to

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go fishing, or must be driven with the sheep, cows and hogs to his segregated feeding trough.

It will not be long until the incompetent will not be allowed to grow food for other than their own consumption. To farm for profit will require proper licensing as required now for teaching, doctoring, and preaching. Farming for profit under license requirements is preferable to farming without profit, as millions now do. The high cost of ignorance is reflected in present low standards of eating throughout the world, in the malnutrition due to lack of essential elements because of improperly grown plants for food of beast and man, and in the awful waste of food transportation, food storage, and political blundering. This will be largely done away with, after the hydroponicum is established as a part of the equipment in households around the world. And it will not be difficult to do so, for once the missionary, the teacher, the county agent and, in time, others get going on this thing, people of the world will catch on quickly, and will make their own tanks out of any and everything handy.

Below and above the giant dams being built for watershed control, along the main and tributary streams large-scale hydroponic systems will cover the now unused areas, to be operated privately, in cooperatives, or under government control, for providing canning and freezing units with the food-storage requirements, which will not be as necessary then as now.

Paradoxically, more people will be engaged in growing plants than are now. Most of them will be growing for their own use, or for profit. The countryside will be more populated, and the lake resorts will be home, rather than a place to visit. For it will be more pleasant to live in the country, as well as profitable. While the hard labor and

ILLUSTRATION 13. A mess of Lima pole beans, grown by Dr. Charles Deevers in his Spessard-type of hydroponicum at Clinton, Mississippi. Photograph by Dr. Deevers.
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the hired labor will be eliminated largely, the delightful labor of tending the growing plant will remain. And this must in the end be of inestimable aesthetic and spiritual value to the whole nation that succeeds in going hydroponic.

The mule, the plow and harrow, the tractor, all are on their way out.

The tanks are coming.

ILLUSTRATION 14. Showing the feeding arrangement for the Spessard-Hydroponicum as used by Mr. J. M. Hammock, a successful operator in Corpus Christi, Texas. The tomoat plants shown were six weeks old at the time the photograph was taken.

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A4

GUIDE TO

Radio Control

THEORY
PRACTICE
and
OPERATION
of
RADIO
CONTROL

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INTRODUCTION

There is a mistaken idea that radio control is difficult, that one must bone up on the science of electronics in order to operate an RC plane, boat, auto, or what-have-you.

The truth is that anyone can install and operate successfully the radio equipment now available at the hobby shops using just the manufacturer's directions. But for the newcomer to avoid commonly made mistakes and misunderstandings inherent to any field where written directions must be interpreted and applied, it is desirable that the beginner benefit from the advice of fellow hobbyists already successfully started, and quickly obtain a little first-hand experience with the practical fundamentals.

Unfortunately, this isn't always possible. When he finds such a course impossible, the beginner naturally turns to books and magazine articles. The books usually are written by some electronics expert who provides plenty of theory and a minimum of practice, magazine articles are scattered piece-meal over a period of years.

This booklet is intended, therefore, to give the practical kind of information that will assist the interested reader in building and operating his radio control model. While the practical side of RC modeling is emphasized, enough background information about radios and equipment is included to round out the picture.

However, the booklet is not limited to the beginner. After the thrill of the first few successful operations, the hobbyist comes up against the problem of maintaining reliability. The information herein not only will help you get into the air, but it will assure you satisfactory operations month in and month out.

Happy flying!

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Chapter One

THE PICTURE

Before the Federal Communications Commission a few years ago granted, for the (among other) purposes of controlling model planes, boats, etc., by radio, the examination-free (Citizens' Radio Service) frequencies of 465 and 27.255 megacycles, this "RC" hobby was limited to licensed amateurs or "hams." The hobbyist could build his own model provided he was willing to have some radio amateur operate the controls for him. Model builders lucky enough to possess "tickets" and who, consequently, could operate their own models—such as Jim Walker, Walt Good, Joe Raspante—became famous because they were masters of something that was mysterious, presumably costly, and not available to the rest of us.

Today, radio control is simple enough for any moderately skilled builder to master and, although more expensive than other types of modeling, it is within the financial reach of many hobbyists. The combined cost of plane, engine, supplies, and complete radio equipment may be less than $90. By assembling his own transmitter and receiver from parts, the builder may realize further savings. On the other hand, elaborate equipment for operating three, five, or even more controls, may be purchased at prices from approximately $150 up.

For prices and descriptions of the various radio control outfits on the market, the reader is referred to the advertisements appearing in the current issues of the various model airplane magazines. Technical, descriptive matter about their products may be obtained by writing to the manufacturers listed in the advertisements.

While the two frequencies set aside for us modelers, as mentioned above, are loosely described as "license-free," they actually are only "examination free" and you get your license by filling out and mailing to, or bringing to, the nearest FCC field office, the printed form 505 you found with your new radio equipment when it comes from the factory. This application form also is available from the FCC. All the transmitters and receivers currently advertised in the model plane field operate on these convenient examination-free frequencies.

In its simplest form, the typical radio control outfit consists of a transmitter, a receiver, a sensitive relay (usually part of the receiver, although it is sometimes mounted separately from the receiver), and an actuator (usually an escapement device), for moving the control surface or surfaces. A signal sent out by the transmitter is detected or picked up by the receiver: this signal causes a change in the amount of electrical current flowing through the receiver's tube. It is this current change that causes the relay to operate—either opening or closing the relay, depending on the type of receiver. The relay then closes a contact to complete a circuit that permits electrical current to flow to the actuator which moves the rudder right or left to steer the plane or boat. The most typical actuator, the escapement, is an electromechanical device. When energized by the electrical current, its magnet causes a revolving arm to be released to provide the physical force necessary to move the control surfaces. This force is available from a twisted or wound-up loop of model airplane rubber.

The overwhelming majority of radio control models are flown by means of a single control, the rudder. The capabilities of rudder-only control should not be underestimated. Possible maneuvers range from simple turns and stalls, to wing-overs, Immelmans, rolls, lazy eights, loops and spirals. With rudder only you can complete the standard AMA rules precision pattern used at contests. Although multi-control planes can do extra stunt maneuvers, such as vertical dives, outside loops, and inverted flight, the lighter, rudder-only jobs have often outpointed far more expensive and complex equipment, even at the National Contest. The 1955 National Contest, for example, was won by a rudder-only airplane.

Escapements may be combined in certain ways, with a single channel radio, to permit limited motor and/or elevator controls. A skilled flier, therefore, can tackle successfully such advanced maneuvers as inverted flight with the cheapest receivers on the market. Multi-channel receivers with appropriate actuating devices do provide a smoothness in elevator control not readily obtainable by other systems and allow precise trimming of the machine while in the air. Rudder only is recommended for beginners.

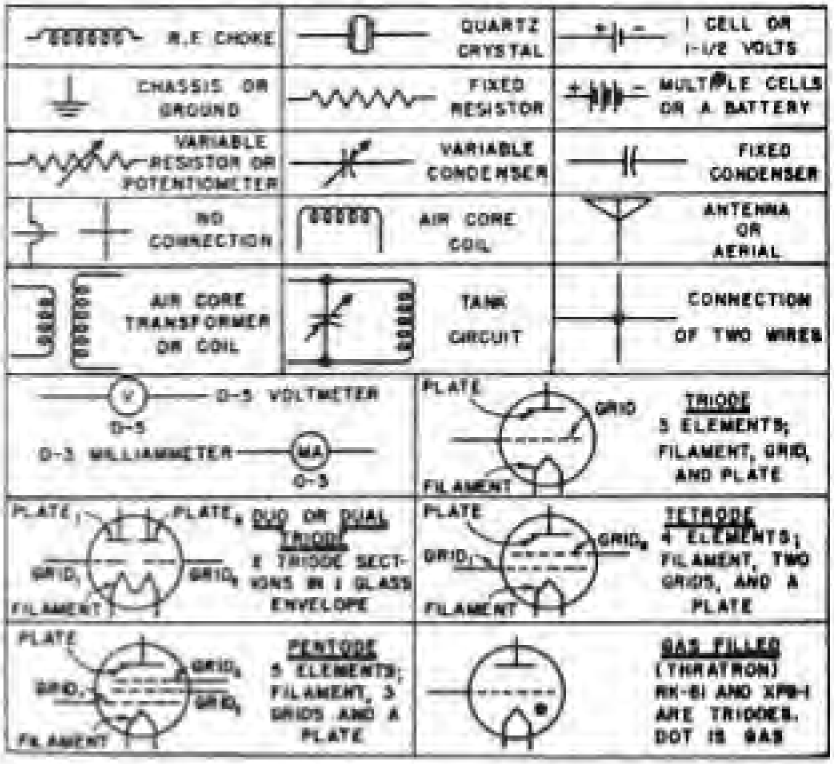
The usual method for moving the rudder is a self-neutralizing type of escapement. When a signal is transmitted, the rudder is moved either left or right. The rudder will remain in that position as long as signal is maintained; when the signal terminates, the self-neutralizing escapement returns to a neutral or no-control position, hence its name. So the length of the signal, determined by how long you hold shut the transmitter keying switch or button, determines the amount of turn and bank imparted to the airplane. Upon the next signal, this type of escapement will move to the opposite position. For example, if right rudder had been applied first, the next signal would produce left rudder. This sequence makes it necessary at times to pass quickly through the unwanted rudder position, to obtain or to continue turn in the desired direction. This is easily accomplished because transmitting a signal, which is instantly terminated, does not give the rudder time to affect the flight path of the airplane.

One that allows either left or right turn at will, and possible use of a second control, is the compound type of escapement. This device is designed to give one rudder position—let's say right rudder—upon one signal impulse from the transmitter, and to give opposite, or left, rudder, upon two signal impulses. Three quick signals close an electrical contact in the compound escapement, causing the auxiliary escapement to close and move the additional control. Various electric-motor driven devices or servos may be substituted for escapements. Modelers have devised variations of this basic system for obtaining precise control in the air, but always at the cost of more things that can go wrong.

By the addition of an electronic or mechanical pulsing device—sending out a steady flow of signals, and using a magnetic type of actuator which slaves accurately following those signals—a proportionate type of control may be had. It is possible to vary the rate of the pulsing, or the length of the pulses, or both simultaneously, to obtain multi-control effects with a single-channel radio. However, such systems require much home building of equipment, although useful devices are beginning to appear on the market.

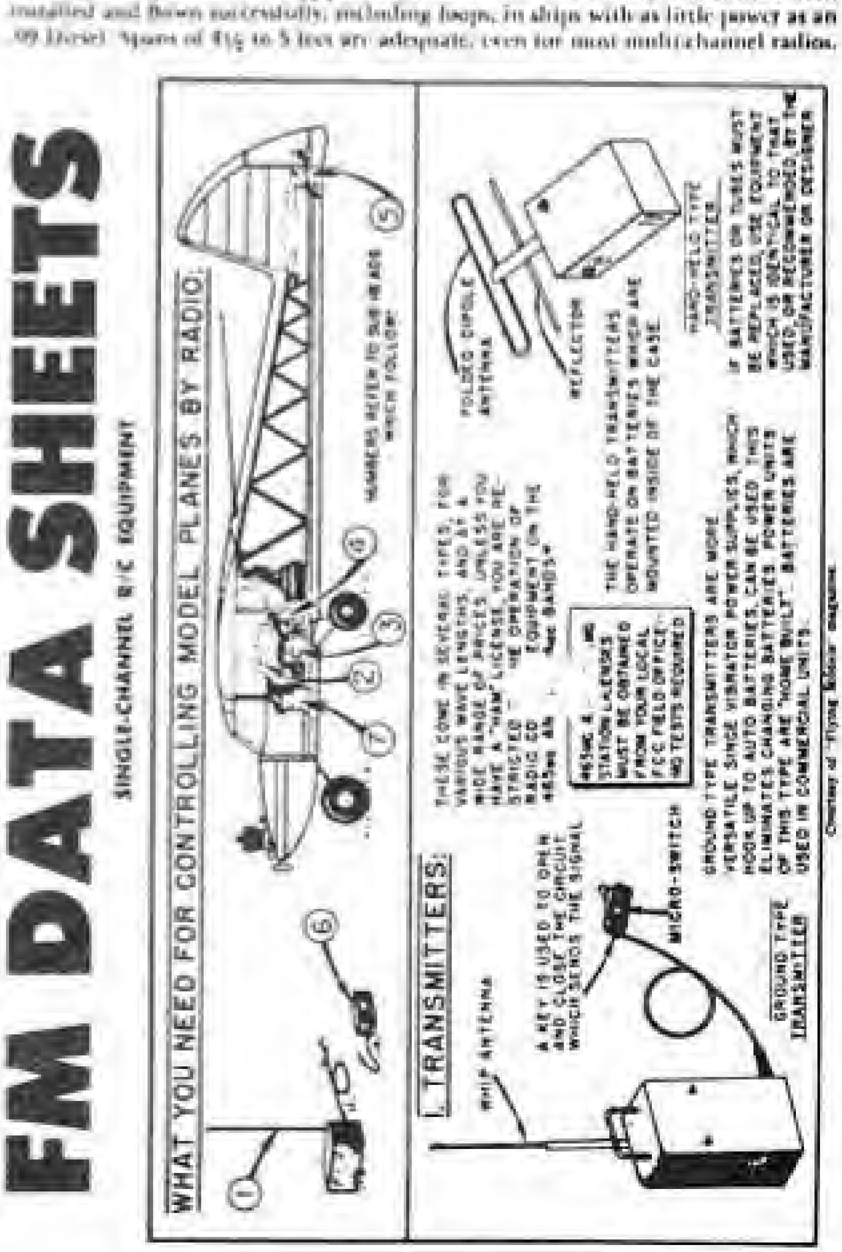
Most model radio operates on a straight carrier wave (CW). This wave is transmitted to the receiver only when the transmitter switch or button is closed. However, some equipment, particularly the multi-channel, operates by tone modulation. With these transmitters a steady carrier wave is sent out as soon as the unit is switched on. Then, when the operator closes a switch or button, a tone is imposed upon the carrier wave. A single channel receiver for tone operation responds to a rather wide range of tones but multi-channel receivers, by means of filters or reed banks, apply particular tones to particular control movements.

From one to six channels are used to work elevators, rudder, and engine. For example, one channel might be used for left rudder, another for right, one for up-elevator, one for down, and another for engine. With a compound escape-



ment or other escapement-servo combinations, two channels adequately operate as many as five controls. Multi-channel set-ups, numerous controls, complex airplanes, gadgetry, etc., should be left to builders with a good foundation of flying experience.

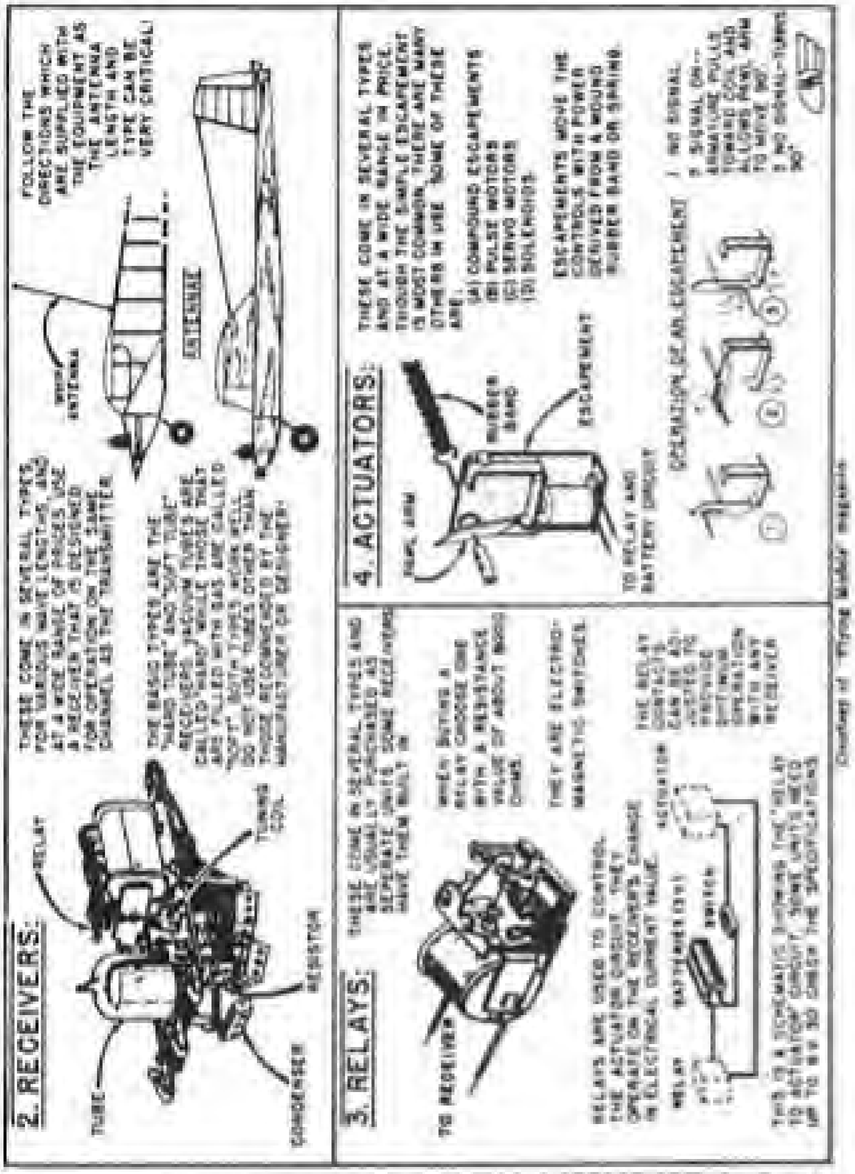
Large, heavy, and powerful airplanes are not necessary in order to carry radio equipment. For the biggest and heaviest receiver, complete with batteries and actuators, a plane with approximately six feet of span, with an engine displacement of .35, grossing at the most 7½ pounds, is sufficient. Five-channel radios have been installed and flown successfully, including loops, in ships with as little power as an .09 Diesel. Spans of 4½ to 5 feet are adequate, even for most multi-channel radios.

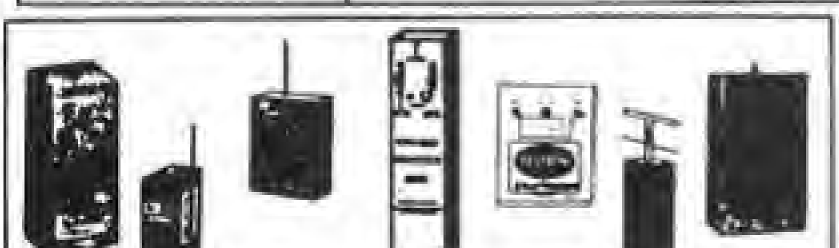


At the other extreme, three to four foot planes with .049 Half A class engines for power, have become very popular. The all round airplane would have between four and five feet of wing, and would be powered accordingly with an engine between .09 and .19 displacements.

Kits of all size RC models are available at your hobby shop. The model airplane magazines publish construction articles and their full size plans may be purchased from the publishers. To a smaller degree, radio-controlled model boats, kits and plans are similarly available.

Which kit you buy, or what magazine plan you work from, depends on the size of your flying area, your work bench, and your pocket book.





Chapter Two

TRANSMITTERS

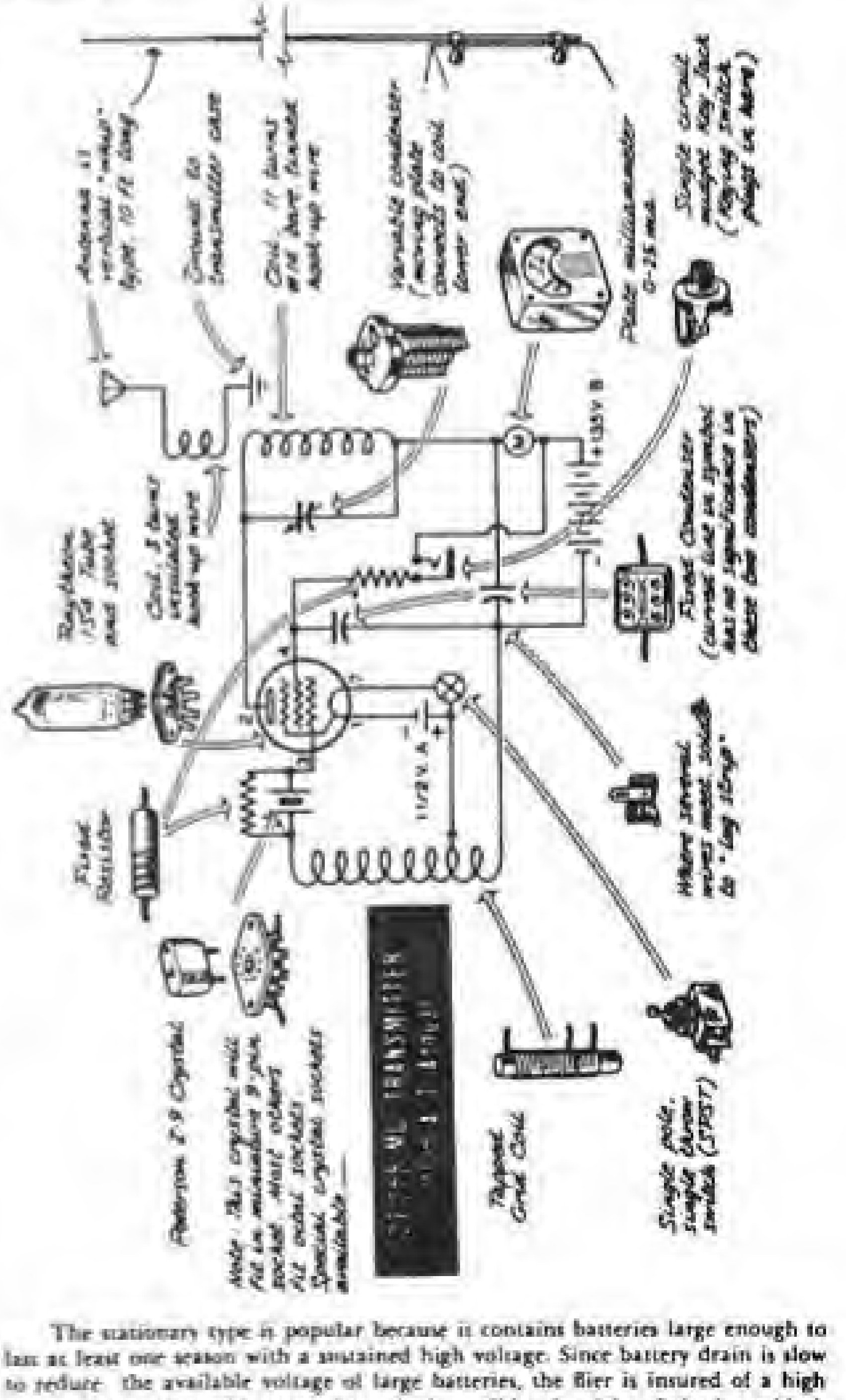
As far as external appearance is concerned, two basic types of transmitters are used: the hand-held type, and the stationary type. Each has advantages and disadvantages. For all the frequencies used for modeling purposes, a hand-held transmitter exists, but the stationary type is not suitable for 465 megacycles. The 465 transmitter is highly directional, and is aimed at the airplane, and therefore is limited to the hand-held arrangement. Another interesting fact about 465 is that the transmitter is not crystal controlled, as are the 27.255 units; but, on the other hand, only an approved factory-made transmitter may be used according to FCC regulations. So you cannot make and operate your own 465 transmitter under the law.

The main advantage of the hand-held type is its convenience on the field; the flier can walk away from cars, people, or other obstacles. He can take up a position near the landing spot, which insures a higher percentage of good close by landings. It is difficult to hit a spot from a distance, or when standing to one side of the flight path of the airplane. Also, the transmitter may be held in any desired position, enabling the operator to place the antenna in any desired relationship to the position of the plane's antenna while it is in flight. This avoids placing the plane in a "null" or blind spot and increases reliability.

The wave pattern of the transmitted signal varies with the type of antenna used. The vertical "whip" antenna is almost standard for modelers. Each type has its areas of strong and weak signal strength and usually there is a small dead spot or null. With the whip antenna this null is directly overhead, lying within an inverted cone of approximately 15°. Actually, the model generally is responsive even overhead except at high altitudes. The plane quickly flies out of a dead area anyway. If not, have your helper tilt the transmitter to incline its antenna.

This is the reason why a hand-held whip antenna should never be pointed at the airplane. Also, the receiver's antenna should be the same type as that used on the transmitter. A light music wire vertical whip antenna may be attached to the fuselage. When a loose wire antenna is stretched from cabin to rudder top, it may be found during ground checks that range is lost when the ship is held horizontally, broadside to the transmitter, and is then rotated through 360°. With the hand-held transmitter this is not so important because the transmitter is readily tilted to maintain signal strength to the receiver.

The biggest disadvantage of the hand-held type is its inability to contain large batteries within the case; however, one set of batteries may last an occasional flier for a season, and several sets should suffice for the most active flier. The hand-held type is easily used: simply extend or insert the antenna and you are in business.



The stationary type is popular because it contains batteries large enough to last at least one season with a sustained high voltage. Since battery drain is slow to reduce the available voltage of large batteries, the flier is insured of a high average output from his transmitter. And, possibly, the sight of the large black box is reassuring, even though the "works" occupy a small portion of the barnlike interior! Placed upon a car roof, the stationary type performs most effectively, the metal roof acting as a ground plane reflector. This type of transmitter does limit the pilot to one location.

In any discussion of transmitters and receivers the subject of tubes comes up

Although the tube may be capable of performing various functions, such as amplification, it is used in the typical single-tube transmitter to generate oscillations, as an "oscillator." The frequency of these oscillations is determined by the choice of other components. This oscillation frequency is referred to as Radio Frequency or "RF." This RF output radiates from the antenna.

When the filament in the vacuum tube is heated (by the A batteries), it throws out huge numbers of electrons. Given a positive charge of electricity (by the B batteries) a near-by metal object (the plate) will attract these electrons. They then flow toward the plate. In the oscillator tube there is a third object, the grid, which is placed between the filament and the plate. When negatively charged, the grid interrupts or stops the flow of electrons toward the plate. When positively charged the grid allows the electrons to flow. The grid, therefore, controls the oscillation of the tube. This type of tube is known as a triode. Other tubes may have two or even three grids or screen grids, are known as tetrodes or pentodes.

Most of the single channel transmitters on 27.255 megacycles employ single tubes, such as the 3A5, 3V4, and 3D6, with a 1½ volt A or filament battery, such as the Burgess 4F or its equivalent in other brands, and 135 to 180 volts (depending on the tube and make of transmitter) B or plate supply from a wide variety of batteries, choice being determined by space available in the transmitter. The A batteries may also be flashlight cells, doorbell batteries, etc. Typical B batteries range from Burgess XX-45's to M-30's, or the brand equivalents. The 465 transmitter uses a CK5703 tube and requires a six volt battery, such as the Burgess F4PI.

The technically minded reader should consult available tube charts and catalogues. Transmitter schematics and their component parts are indicated in manufacturer's directions accompanying their equipment, or may be found in various model and radio magazines.

For greatest reliability install a 50 milliammeter in the B-plus line of the transmitter in series with the keying lead. The advantages of a meter are truly important. For example, the flier will know roughly what reading his meter should show when the transmitter is in tune. He will note abnormally high readings, dangerous to tube and crystal, and indicative of bad tuning. The meter will help him tune the unit. If there is evidence of failure somewhere it is easier to determine whether it is the transmitter or receiver that is causing the trouble.

Transmitter output varies in accordance with operating conditions and, for best results, retuning may be required to suit those conditions. This is especially true of some of the stationary types: a strong signal may be sent out with the unit on top of a car but when placed on the ground, the transmitter becomes detuned and no signal is produced. Such characteristics depend on the design of the transmitter more than anything else. Multi-tube transmitters are less subject to detuning. Large rubber suction cups or "feet" may be fitted to the underside of the troublesome box to minimize tuning changes with changes in the location of the transmitter.

The output of the hand-held type varies, depending on whether it is being held firmly in the hands or placed upon a bench, etc. The body acts as a ground or reflector.

A field strength meter is not a necessity but, sooner or later, it will pay off in detecting failing output of the transmitter, as might occur from bad tuning, poor tube, bad switch, faulty leads or ailing batteries. It is most helpful when tuning the transmitter; what counts most is what the transmitter actually puts out (as shown by this meter) more than the amount of current drain as shown by the milliammeter. The built-in milliammeter, though an important adjunct, does not necessarily prove that the transmitter is developing good signal strength.

Speaking of meters and tuning, it is important to know that the maximum signal strength of a transmitter is not always at the amount of milliamperes or "mils" drain (on the milliammeter) recommended by the manufacturer. This is why a field strength meter, giving actual output rather than drain, is the only accurate check on your output.

Most transmitters used by the examination-free fliers are one-tube affairs. Low cost is a factor. While such transmitters are adequate, some modelers, with an ability to tinker, go in for two or more tubes where the output of the oscillator tube is amplified by the second tube which actually transmits the signal. This decreases the load placed upon the first tube, increases tube and crystal life, and provides a more stable and reliable transmitter. However, the writer has made thousands of flights with single tube transmitters and the occasional failures have been traceable to faulty switches, broken battery leads, and so on.

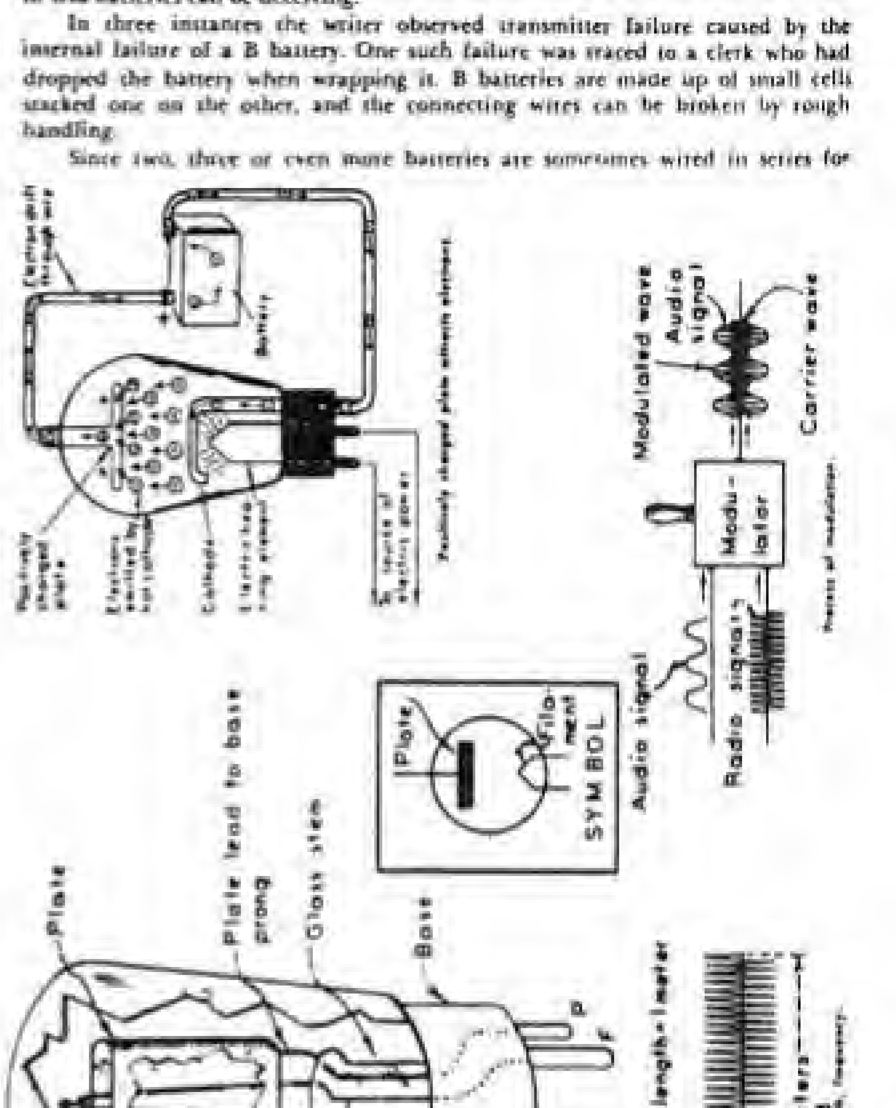
In the audio or tone modulation, multi-channel transmitters, more elaborate circuitry is necessary. Two, three, four, even more tubes may be used. Such transmitters are a deluxe item from a modeler's point of view. But they are essential for reliable tone operation.

Hand-held transmitters for single channel use are operated by means of a conveniently placed microswitch or push button, the former gives a more delicate feel and an audible click, helping smooth out the control of the aircraft. One multi-channel hand-held transmitter has a built-in stick for operating the ground control unit, which is a small device for determining which tone is sent out by the transmitter. This stick may be turned left, right, forward, or backward, giving left, right, down, and up movement respectively. An extra push button on this transmitter box (or on the ground control unit, if it is separate from the transmitter) is used to get a change in engine speed. The stationary type of transmitter sometimes has a built-in push button but almost invariably is equipped with an easy-to-use flexible keying lead to which the microswitch is attached.

It is extremely important that no frayed ends complete a contact between the two wires of the keying lead, otherwise a steady signal could result and the plane could spiral into the ground. A routine check of the transmitter should be made before every flying session. Check voltages under load: transmitter turned on to check the A battery, button closed for signal-on to check the B batteries. Hold the button on for five or six seconds to note whether or not the voltage begins to fade. By doing this, you may detect a B battery that can't take it. Old batteries can be deceiving.

In three instances the writer observed transmitter failure caused by the internal failure of a B battery. One such failure was traced to a clerk who had dropped the battery when wrapping it. B batteries are made up of small cells stacked one on the other, and the connecting wires can be broken by rough handling.

Since two, three or even more batteries are sometimes wired in series for



transmitter B voltage, it is a good idea occasionally to read individual voltages, rather than just the end voltage. Sometimes one battery will be found to sag, or to read noticeably less, thus dragging down the entire set. Even a new battery cannot be taken for granted. When batteries fit loosely within the transmitter case, they should be tightly packed against movement with wadded paper or sheet balsa. Where terminal posts might come into contact with the metal case, cement thin, protective wood against the case, or cover the posts with some kind of tape. Look over the various wires and soldered joints. A nut on an antenna post may work loose, and a lead fall off.

Some advanced fliers avoid variable battery voltages by eliminating B batteries entirely. This is accomplished with a power pack which is connected by leads to the automobile battery. This unit converts the car battery voltage into the proper voltage for the B supply of the transmitter. A 22 ohm, 1 watt resistor will cut the 6V supply to 1½ volts for the A supply.

Although such a power supply eliminates all worries about batteries, or their cost, it does make the flier more immobile than ever on the field and increases the things to be done before the model can be flown. Qualified hobbyists can make such units, but finished items are available from radio suppliers who advertise in radio and model publications.

The newcomer to this field frequently assumes that good range is not possible with the typical receivers and low output transmitters he sees in use. For the examination-free flier, the FCC limits the input to the final tube of the transmitter to five watts maximum. The number of watts is easily computed, one watt being equal to a current flow of one ampere at one volt. Voltage is multiplied by milliamperes. If, for instance, the voltage were 135 and the current flow 20 mils (a mil, or milliampere, being one-thousandth of an ampere) the input would be 2.7 watts. Actual output of the transmitter is less.

Good equipment, properly tuned, with good batteries, will operate reliably at a distance too great for the flier to maneuver the plane without the aid of binoculars. Licensed amateurs usually resort to much higher input on other frequencies, sometimes with less sensitive receivers, because this reduces the chances of interference. Reliability is increased with reserve output, as the signal strength may make up for some accidental deficiency in the receiver during flight.

A five-watt input transmitter may be capable of a one mile ground check with a sensitive one-tube receiver. Multi-channel equipment with as little as ½ watt input have ground checked up to several miles with three (or more) tube receivers.

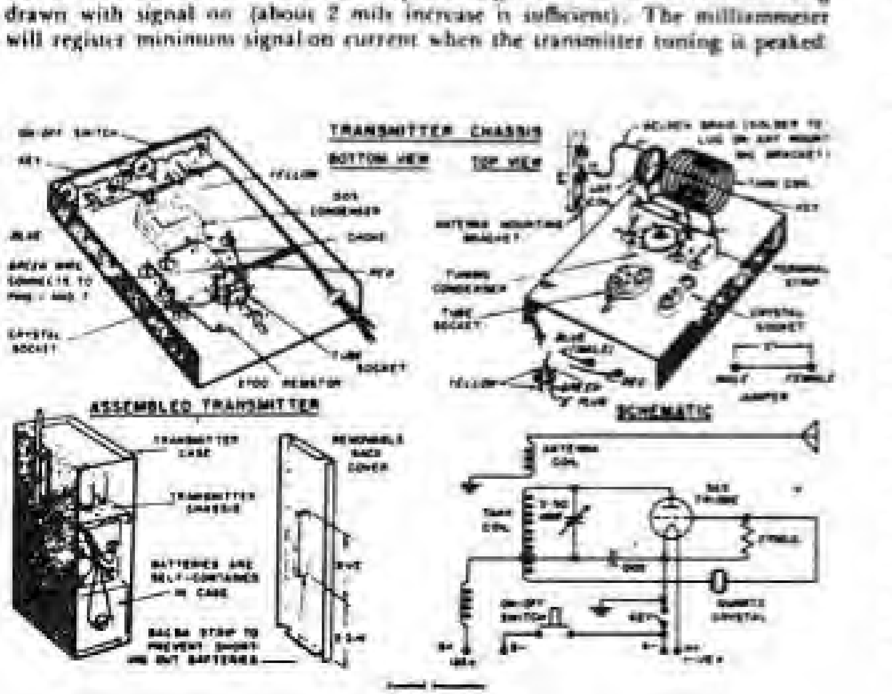
Assuming that everything is in good working order, range depends on proper tuning of the receiver to the transmitter and correct tuning of the transmitter itself for maximum output. The manufacturer builds into the transmitter a variable tuning condenser which may be turned in or out, to increase or decrease capacitance respectively. This operation is done with a tuning wand, or rod, made of non-conducting plastic, bakelite, etc. These wands are inexpensive. When tuning the transmitter keep in mind that exceptionally high currents may burn out the tube or crack the crystal. For this reason, milliammeters are an important part of every modeler's equipment. Indispensable for tuning the receiver is a 0 to 3, or 0 to 5, milliammeter. Desirable for transmitter tuning is a 0 to 50 meter. Meters vary greatly in price but any sold through the hobby shop are acceptable. A cheap meter for the transmitter serves just as well as an expensive one. The receiver meter should be calibrated against some other modeler's more expensive meter and adjusted to give corresponding readings if necessary.

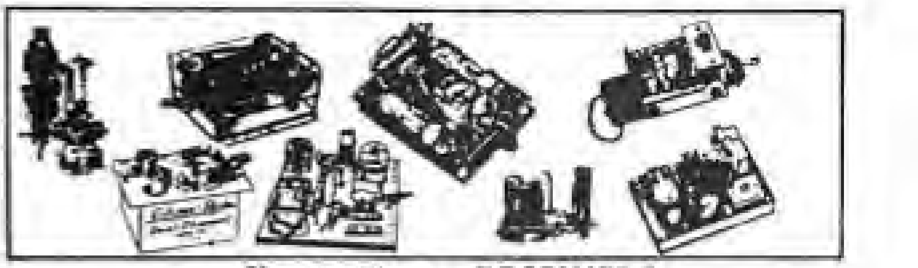
A 50 mil meter should be inserted into the transmitter B-plus lead, if there is no meter built into the box, to begin tuning. With signal on, tune to obtain the reading specified by the manufacturer or known to be approximately correct for your transmitter. If you have a field strength meter, further tuning adjustments may be made. In a pinch your receiver will substitute for the field strength meter. Once the receiver is tuned to the transmitter for maximum rise or drop, depending on the type of receiver involved, further tuning may be found to increase that rise or drop, a sure sign of higher output.

It is bad practice, however, to tune the transmitter for absolute peak output. It will be noted that when the tuning condenser is turned too far one way, the reading on the milliammeter will begin to rise slowly, too far the other way, and the reading will shoot up abruptly. If you are using a field strength meter in conjunction with the milliammeter, also note that the signal strength drops off slowly when the transmitter tuning is varied too far in one direction, or very abruptly in the other. What is happening? What should you do?

Visualize the wave as a long steep hill, followed by a near-vertical drop. As you turn in the tuning condenser, increasing the capacitance, you gradually tune the transmitter higher and higher up the long slope. If tuned at the very peak, there is a chance that the tuning may wander enough to fall off the near-vertical side, down to the valley floor, so to speak, and the transmitter is then out of tune. This is because the capacitance may be varied by movement of your body close to the transmitter or by changes in the position of the keying lead. Peaked tuning can cause loss of control in flight.

The correct method is to tune until the peak is found, then back off on the long slope side of the peak until a slight loss in power output is noticed. This will show up on the field strength meter as a slight drop from maximum reading. On the milliammeter it would show up as a slight increase in the current being drawn with signal on (about 2 mils increase is sufficient). The milliammeter will register minimum signal-on current when the transmitter tuning is peaked.





Chapter Three RECEIVERS

The most widely used receiver is the single-tube type. However, two-tube types, in which the second tube is used to step up the current available to a relay, also are popular. Several more advanced types for tone operation, utilizing three or more tubes, also are on the market, these being associated with more complex models and flying technique.

As to the less costly types in wide use, there are two distinct kinds, each with special advantages. One uses a gas tube, such as the Raytheon RK61 or the English Hivac XFG-1. Both of these tubes use 1½ volts for filament and 45 volts for B or plate supply. The other type uses the hard tube, such as a 3V4. What is the difference between a gas tube and a hard tube?

The gas tube is one in which an inert gas has been injected inside the envelope; it glows with a dim purplish light which diminishes noticeably when the current flowing through the tube is reduced, as when a signal is received. The hard tube is one from which the air has been evacuated, as in an electric light bulb. The gas tubes are said to be more sensitive but they do not last as long. Either type of receiver can be carried by an .049 engine. The hard tube almost certainly will outlive the airplane.

The gas tube receiver requires the use of a potentiometer or "pot," as it is always called on the field, built into the plane. Its purpose is to maintain a recommended idling current (which is read on the milliammeter inserted into the jack wired into the B plus lead). Hard tube owners usually install the potentiometer anyway because it is handy (on either type of receiver) for checking the relay pull-in and drop-out values. With the hard tuber, however, the potentiometer may be attached to the meter itself and does not have to be carried on the plane.

The life of the gas tube is related to the amount of current at which the receiver is operated. Usually this idling current is 1.5 to 1.5 mils. Upon signal the current will drop to .5 of a mil or less at a distance, if everything is in order. Without the potentiometer, the gas tube would idle at several mils, probably far more, and would quickly burn out. Its sensitivity becomes less as the idling current is increased, gas tubes being most sensitive at lower idling currents, particularly when new. A new tube that appears insensitive at a higher idling current may be satisfactory when the current is turned down by means of the potentiometer; for example, 1 or 1.1 mils. It is not practical in one-tube installations to reduce the idle further because a margin of safety is required above the relay setting—at least .2 mil in practice.

When new, a gas tube may show up well on bench tests but have a very limited range on the field. In this case, idle the tube for 15 minutes at 2 mils and recheck. Usually, the range improves. Sometimes several such idling periods are needed.

Both the RK-61 and the Hivac have long wire leads which are clipped to the desired length for mounting. Most radios using these tubes have small fuse clips into which these wire leads are inserted, the tube being held firmly to the chassis by means of a rubber loop. The leads should never be soldered to the clips, nor should solder be permitted to flow up through the wire connection below to the end into which the tube leads fit. The heat from soldering can damage the gas tube. Small tube sockets, called Cinch hearing-aid sockets, may be found at radio supply stores. Never use acid core solder as corrosion and electrical leakages result. Use a good resin core solder such as Kesters.

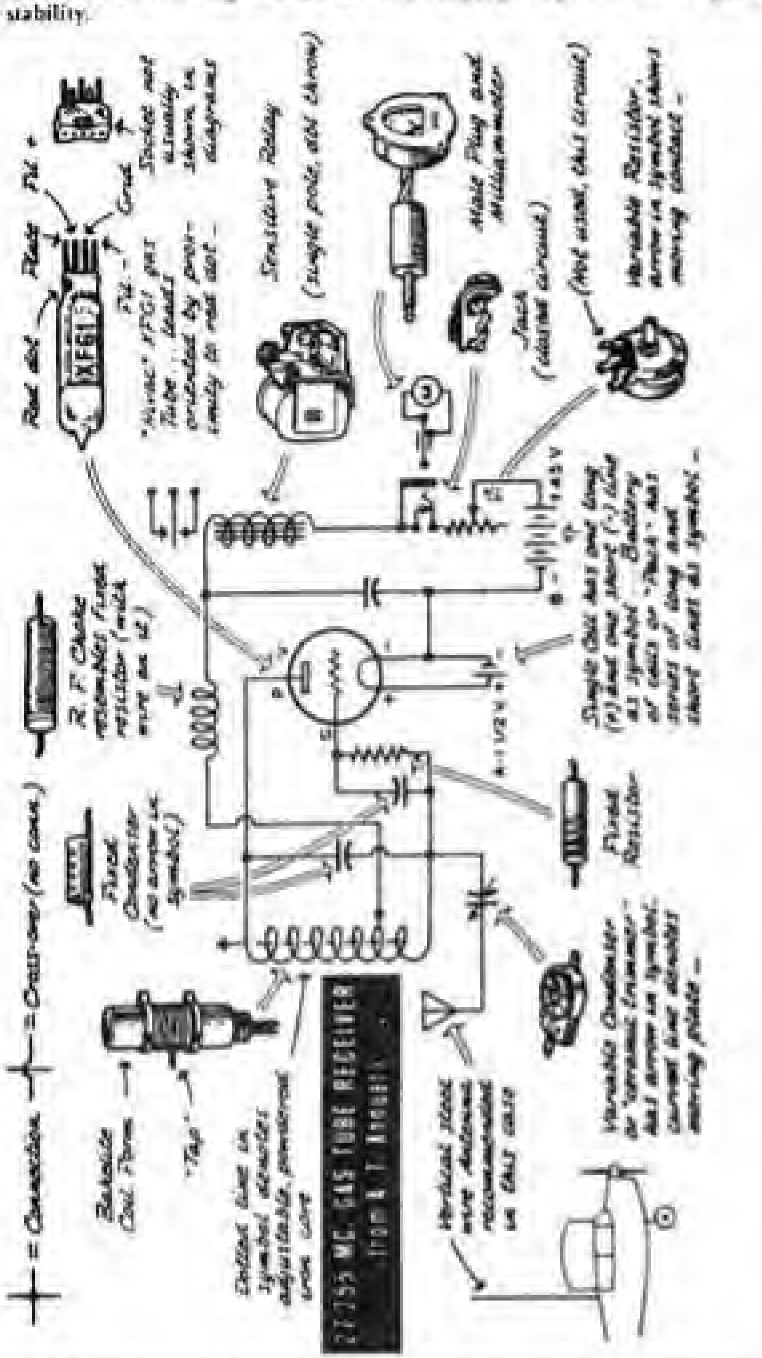
Idling current of the hard tube, on the other hand, may be anything that results from use of recommended batteries and, depending on the tube, will vary from 1.5 to 7 or 8 mils. For practical considerations, it should be unnecessary to require more than 3, certainly 4, mils. The current, upon receipt of signal, does not drop to near zero as it does with gas tubes, but the actual amount of current drop or current change between, say, 2.2 mils idle and .8 on signal, is roughly the same as it would be with the gas tube.

The hard tube receiver sometimes has two tuning controls, one for controlling the idle current and the sensitivity of the receiver, often referred to as the sensitivity control; the second, for tuning to frequency. There is a certain amount of interplay between the two. If manufacturers' directions are followed in either case, tuning will prove easy. One odd thing that must be guarded against when tuning receivers is any condition that affects the radio, leading to detuning when those conditions are removed. For example, a type of receiver that displays sensitivity to body capacity requires careful handling. Don't lean against the antenna while tuning, etc. In general, the farther that the body and hands can be kept away from the receiver and its antenna during tuning, the less likely you are to encounter poor range in the air.

Hard tube receivers which have a sensitivity control should never be tuned for maximum sensitivity. In the air, the plane may become the victim of a fluctuating idling current. Triggering the relay and "rudder walking" would be the least of the undesirable thing that might happen. When tuned too sensitively the hard tube receiver will react with the transmitter antenna—even when the transmitter is turned off—and faulty control results when the ship is in the vicinity of the transmitter.

One check (assuming you do not have the advantage of the manufacturer's

directions) is to carry the plane close to the transmitter with the receiver turned on. If the escapement is operated without a signal being sent, the receiver is adjusted with too much sensitivity. If the ship can be brought to within a foot of the transmitter without this happening, it should be safe in the air. During the ground check, be willing to sacrifice some range, perhaps a .1 mil drop, to insure stability.



Hard tube receivers function as transmitters quite effectively and the more sensitive the adjustment, the more they broadcast. Under certain conditions, a hard tube receiver may spin down another airplane hundreds of feet away. For safe flying, practice keeping your receiver, as well as transmitter, dead while other planes are in the air.

In the gas two-tuber, the second tube is connected into the circuit in such a way that it idles at zero or a small fractional part of a mil but rises to 2 or even 3 mils upon signal, depending on the voltage available and the resistance of the relay. The first, or detector tube, functions precisely as it does in the normal one-tuber, but idles at .4 or .5 mil, sometimes higher. The principal advantage of the system is the large current change available for relay operation

The wide range of relay operation that results, together with greater spring tension and contact pressure, makes the relay virtually vibration free. Some fliers take advantage of this fact to install the relay without benefit of shockproof mounting. Others put such receivers in small but high powered planes or in ships with rough running powerplants.

The 465 receivers employ a 6K4 or 6AK4 tube requiring six volts on the filament. A battery drain is rather high, but small hearing aid batteries for B supply have nearly the equivalent of shell life. The reason for the long B battery life is the low idling current of about .2 mil, which rises to 1.1 to 1.4 on signal. Fliers have found that by using 7½ volts (five pen cells), the A batteries stand up a great deal longer. No harm is done to the receiver. On medium size planes, ten pen cells, or in larger planes, five medium flashlight cells, may be carried without difficulty. A battery life then extends into weeks, or even months.

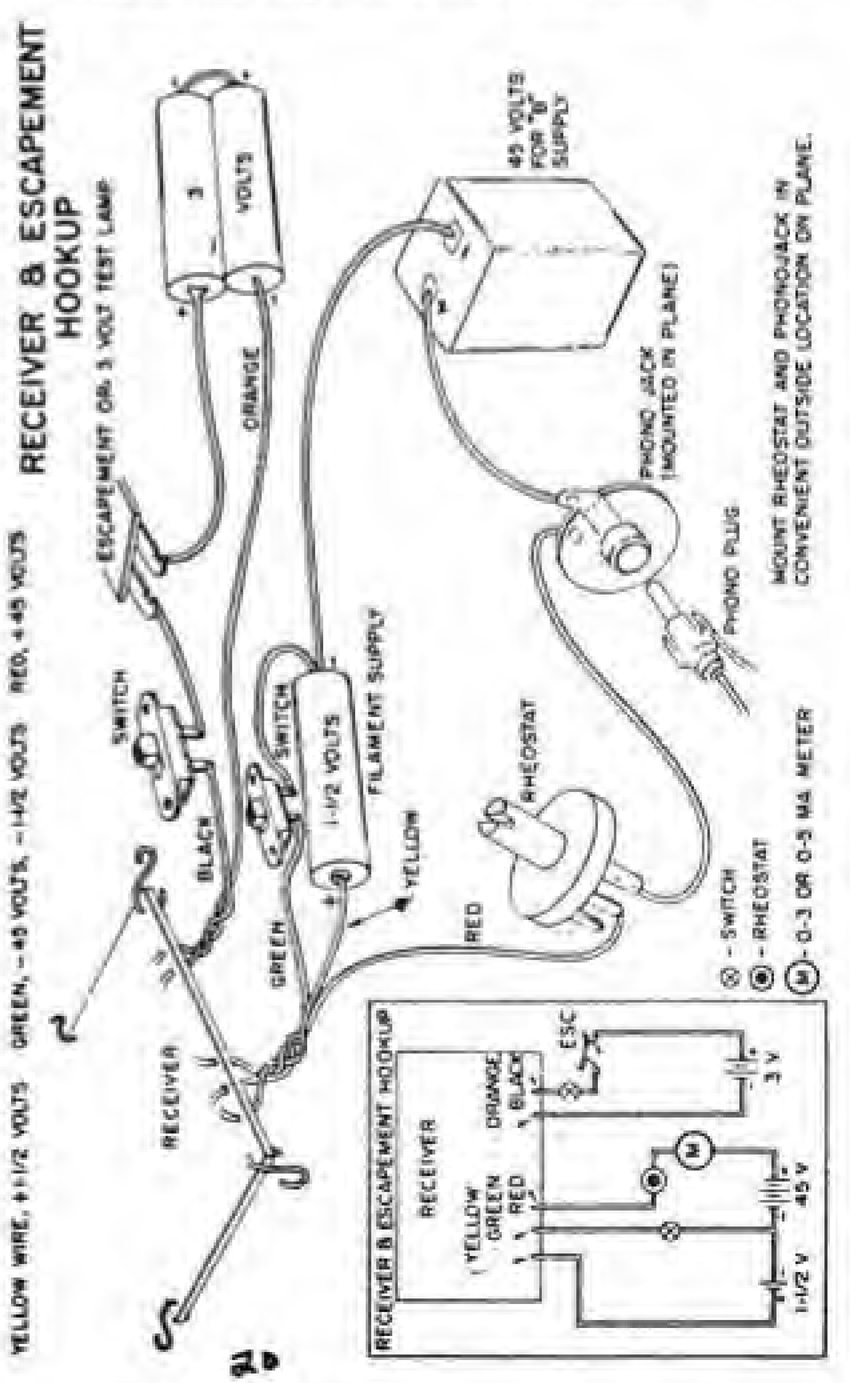
In the beginning, the 465 receiver was not tunable by the builder. Actually, it didn't require tuning, unless damaged, in which case it was to be shipped to the factory for realinement. A newer 465 receiver is tunable, like any other single hard tube receiver.

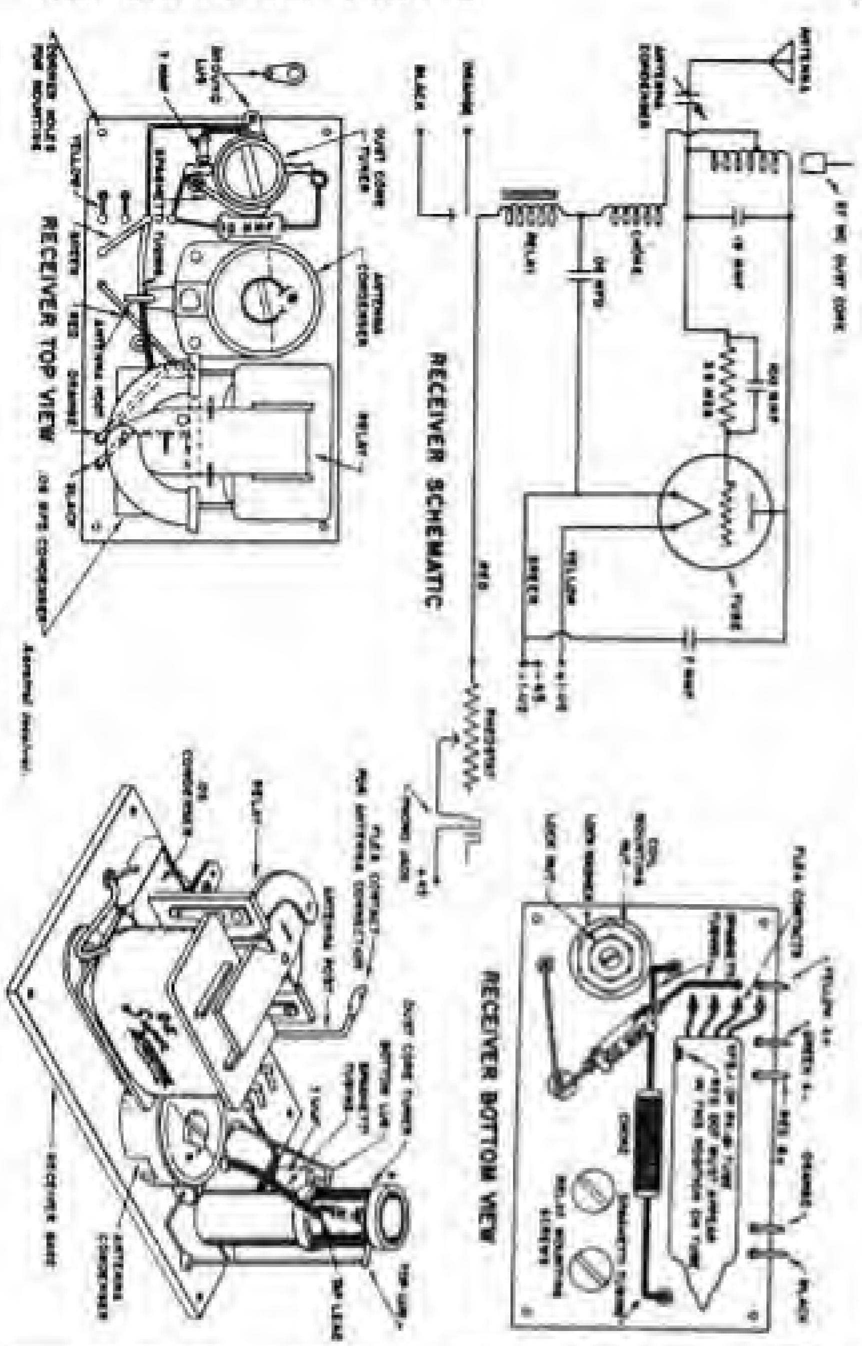
The more elaborate receivers for tone operation and multi-channel work contain many special features. In one case, hermetically sealed relays with a current change on the order of 6 mils are provided. These receivers will not respond to straight carrier signals and obey only the selected tone sent out by their own transmitters. However, a straight carrier wave transmitter, when the operator holds steady signal, will prevent, or block, the tone receiver so that it cannot respond to its own transmitter. But, on the other hand, the tone outfit, functioning as it does with a steady carrier turned on, will effectively prevent anyone ground checking, much less trying to fly, any other type of carrier wave operated equipment.

Advantages of sealed relays are that the contacts do not become dirty and do not require adjustment, the latter because of the substantial current change in this particular type of radio and resulting positive action. These receivers are not likely to be spun-in through out-side interference and will be highly resistant to vibration difficulties because of large current changes in the relays. Whereas single tube receiver uses that tube to perform several distinct functions, the typical tone receiver uses a tube for each purpose, such as detection and amplification. Therefore, it is theoretically the most reliable and stable in operation.

The multi-channel receiver requires a separate relay for each actuator (except when secondary actuators work from a compound escapement or servo). In the case of a rudder drive servo that is moved one way by one channel, and the other way through a second channel, two relays are required for the one servo. Two to five or six relays are usually mounted on such receivers. One manufacturer uses filters to cause the proper tone to operate the correct control; at least three others use a special reed bank in which tuned reeds, vibrating at specific frequencies, respond only to their particular tone. The agitated reed then makes the contact that closes its particular relay, and the relay energizes the proper actuator.

Receivers are installed in the airplane by various means, such as from rubber bands from the four corners of the chassis to hooks onto the cabin walls; or wrapped in foam rubber, or set upon a block of foam rubber attached to a plywood slide. Details are given in the chapter on installations.





Chapter Four

RELAYS

When your receiver comes from the manufacturer, its relay has been properly adjusted. However, it is possible for the relay to get out of adjustment, either during shipment or later, and it certainly will require readjustment from time to time during the lifetime of the model. We would like to say that you do not have to know how to adjust a relay but the unfortunate truth is that, if you expect to fly a great deal, such knowledge is essential–unless, of course, your receiver happens to have a sealed type of relay.

There are, perhaps, a dozen makes of relays that are used in radio models. Of these, the Kurmans and Sigmas are most widely used. It should be pointed out that some relays were not intended primarily for modeling purposes, despite the fact that they are advertised for such use and can, in fact, be used successfully. For example, some suppliers offer a Sigma that originally was designed for electric blankets. It mainly differs from the more familiar Sigma 4F commonly used for RC in that rigid, screw adjustable contacts are not provided. While such relays are genuine, they are not as ideal as the factory supplied job designed for our particular requirements. Whereas Kurmans have not had screw adjustable contacts until recently, the new Model BKA manufactured expressly for Berkeley does have this feature. Sigma's new 26F will supersede the 4F.

The important parts of the relay are the magnetic core or pole piece, the armature, the tension spring, and the contacts. Special directions for adjusting the relay are included with manufacturer's literature – but the purchaser of random relays does not benefit from such directions. A few handy hints will be added here.

All the single tube receivers have a steady current (the idling current) flowing through the relay. On all the single-tubes but the 465, this current is sufficiently high to cause a magnetized core piece to attract and pull in the nearest end of the armature; thus, when the receiver is turned on, the armature automatically pulls in.

When a signal is received, the current flowing through the relay is reduced, and becomes insufficient to hold in the armature because of the tension of the spring. Now being greater, this spring tension causes the relay to release the armature which then "drops out". The other end of the armature will then rest against the lower contact. All the upper contact does, in this case, is to prevent the armature from touching the magnetic pole piece when pulled in, which would magnetize the whole assembly so that it could not function properly. By adjusting the spring tension and contact gaps, the flier can set his relay to operate at any desired current value, as read upon the meter inserted in the B-plus lead of the ship's wiring.

With 465 receivers (and two-tubers) the operation is reversed. Having a low idling current (second tube, in two-tuber) not sufficient to attract and hold in the armature, spring tension holds the armature against the dropped out (lower) contact. When signal is received, the current flowing through the relay increases, the armature pulls in, and rests against the other contact. The live contact, in this case, is opposite to what it was before. It will be noted that when the relay pulls in on signal, the upper contact is wired into the escapement circuit; when it drops out on signal, the lower contact is wired in.

Anything that makes it more difficult for the relay to pull in, will raise the pull-in reading on your meter. More spring tension increases this current, but an excessive gap between the lower contact and the armature (measured when the armature is pulled in) does the same thing. If the upper contact is so set that too much gap results between the armature and pole piece when pulled in, the operation will be marginal and subject to vibration.

The drop-out current depends on spring tension only. For a quick rough adjustment of a Sigma, insert a piece of cigarette package cellophane between the core piece and the armature. Adjust the upper screw contact to maintain that gap when the relay is pulled in. Then the maximum gap between the armature and the lower contact–when pulled in–should be the thickness of a dollar bill. Changes in spring tension should be minimized because they have drastic effect. This procedure applies to both Sigmas and Kurmans operated at typical values somewhere between, say, .8 and 1.2 mils. For single tube operation it is best not to have less than .2 mil difference between pull-in and drop-out.

Narrow gaps are subject to vibration troubles because any movement induced in the armature, or contact arms, may cause touching between armature and the live contact. While higher spring tensions do increase immunity to vibration, they do not do so when the gap is too small.

When the armature is permitted to strike against the core or pole piece, it may become magnetized. Repeated pulsing of the signal may build up residual magnetism until the armature sticks to the contacts, resulting in faulty operation or a crash. Kurmans have the pole piece treated to prevent this condition.

Another relay seeing increased use is the Neumatic. Possessed of high resistance to vibration is still another relay, the polarized type. The armature is mounted vertically, moves back and forth between two screw contacts. A built-in permanent magnet replaces the spring tension feature. Drop-out and pull-in values are controlled by varying the two screw contacts.

Since you will hear the word "ohms" when relays are discussed, it would be well to understand what the term means. The amount of current that flows through a wire, relay coil, or resistor, etc., depends on the voltage applied, the thickness and length of the material, and the nature of the material itself. The resistance to the passage of current is measured in ohms. A resistance of one ohm results when one volt is needed to make one ampere of current flow through the object. Ohm's law states that the Current equals Voltage divided by Resistance. For example, an equipment having 5 ohms resistance when 3 volts are applied, would have a current of .6 ampere or 600 mils.

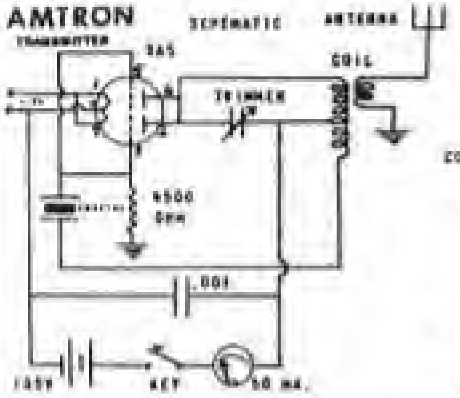
For model use a sensitive relay is desired, one that operates reliably on small amounts of current change. The relays we use have a resistance of about 4,000 to 10,000 ohms. Five to eight thousand ohms are average. Where vibration is a problem or where the relay must operate at unusually low current values, high ohmage is desired because of the resulting greater contact pressures. Low relay settings tend to pit the contacts. Clean contacts are absolutely essential in any relay. It is important that the contacts be cleaned with non-abrasive material. Use a dollar bill or clean piece of paper – never a file or sandpaper. Rough contacts lead to pitting and sticking, and finally complete failure. To prevent "arcing" between armature and live contact, place a 100 ohm resistor and a .1 mfd. condenser in series across the relay contacts.

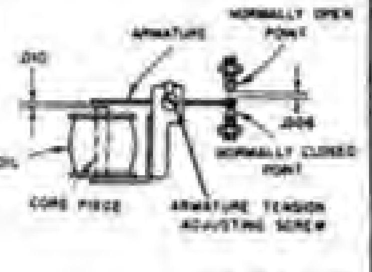
When used with two-tube receivers with a large current increase, a relay may be set with a large movement of the armature and a wide gap. Since the second tube idles at virtually nothing, the relay is dropped out regardless of whether the receiver is switched on or off. Upon signal, the large current increase imparts a slamming action to the armature. The relay may be set to operate over at least a .4 mil difference between pull-in and drop-out, such as 1 mil to 1.4 mils.

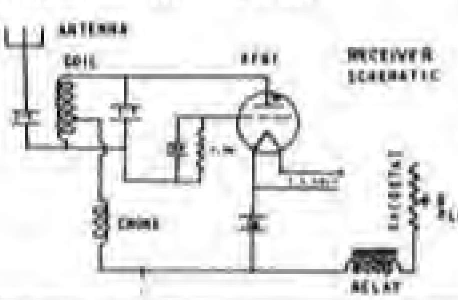
Mounted as part of the receiver, a relay automatically is shock protected against vibration. When mounted separately, it should be given such protection of its own. Some builders put the relay on a one- to two-pound Lord shock mount but must be careful that the relay so mounted does not swing through an arc large enough to strike any object. The relay also may be mounted on a small ply base and suspended in the same manner as the receiver.

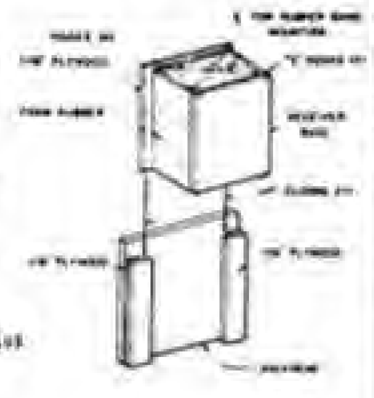
For relay adjusting a test rig may be made, consisting of a cigar box in which may be placed large batteries (as old transmitter batteries). Four pieces of dowel are inserted into holes drilled in the box top. The receiver is hung between the dowels, just as it might be in the airplane. A plug and socket arrangement enables the quick hooking up of the receiver. The jack and potentiometer are installed conveniently in the box top, use a small electric bulb to indicate relay action, instead of the escapement.

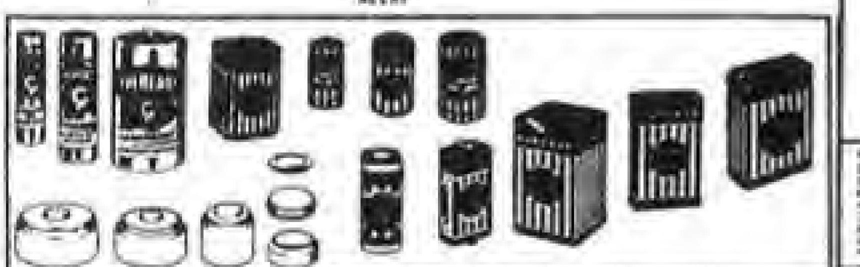
The last pre-flight check of the relay is to try the rudder by radio control with the engine working. If the rudder skips, or does not follow signals perfectly, the ship should not be flown. Sometimes the escapement is at fault but most often the relay is bothered by vibration. Changes in prop size, throttle setting, and so on, may be resorted to but these are tricky methods since engine rpm may change in the air. The relay mounting should be loose enough to avoid vibration. With the receiver properly installed, and the relay correctly adjusted, you should have no trouble with vibration.











hearing aids. When using compound escapements that operate auxiliary escapements, don't use two pen cells when the plane can carry more or heavy batteries. However, two pen cells are not a touch-and-go proposition. As an example of what a small plane will carry, a good .09 engine, with a thin bladed 8 x 5½ propeller, will tote as much as 50 ounces.

Should battery boxes be used? This is a matter of personal preference. Many fliers prefer to make up battery packs, taping batteries together into conveniently sized blocks to fit compartments; the leads are soldered to the batteries. Thus, any possibility of poor battery contacts is eliminated. Also, awkward combinations, such as 5 or 10 pen cells, really require packs.

Lightweight, old style ignition battery boxes require a wrapping of rubber bands, or a spring tightener, to insure good pressure upon the batteries and to prevent the batteries from bouncing loose in crashes and hard landings. Heavier

R.C. BATTERY DATA

USE	VOLTAGE	SIZE	TYPE OF CONNECTION	MFGR AND NUMBER	WEIGHT	EQUIVALENT
TRANSMITTERS	1½	2 5/8 x 2 5/8 x 4 3/32	PLUG 2744	BURGESS 4F		EVEREADY 742
	1½	4 5/8 x 1 5/8 x 5 5/16	PLUG 2744	BURGESS 4FL		
	1½	4 3/32 x 2 5/8 x 4 1/16	PLUG 2744	BURGESS 6F		
	6	2 21/32 x 2 21/32 x 4 1/4	PLUG 2795	BURGESS F4P1		
	6	4 X 1 7/8 X 10 3/4	PLUG 2795	BURGESS 2F4L		
	45	3 5/8 x 2 1/4 x 4 5/16	PLUG 273	BURGESS B30		
	45	3 x 2 5/16 x 4 1/16	PLUG 273	BURGESS Z30		
	67½	2 3/4 x 1 11/32 x 3 11/16	SNAPS	BURGESS XX30		EVEREADY 467
	90	3 1/2 x 1 5/32 x 3 15/32	SNAPS	BURGESS N60		EVEREADY 490
RECEIVERS	1½	3/8 DIA. x 1 3/8	BRASS CAP	(1) BURGESS 7	.2 OZ.	EVEREADY 912
	1½	17/32 DIA. x 1 31/32	BRASS CAP	(2) BURGESS 2	.5 OZ.	EVEREADY 915
	1½	13/16 DIA. x 1 15/16	BRASS CAP	(3) BURGESS 1	1.5 OZ.	EVEREADY 935
	1½	1 1/4 DIA. x 2 1/4	BRASS CAP	(4) BURGESS 2R	3.2 OZ.	
	1½	3/4 DIA. x 2 7/32	BRASS CAP	BURGESS 5ES	1.2 OZ.	
	1½	1 1/32 DIA. x 3 15/16	PLUG 2744	BURGESS TE	4 OZ.	
	22½	19/32 x 19/32 x 1 15/16	BRASS CAP	(1) OLIN 0815	.5 OZ.	
	22½	1 1/32 x 3/16 x 31/32	FLAT BRASS	BURGESS U15E	1 OZ.	EVEREADY 412
	22½	3/4 x 1 1/2 x 2 3/32	FLAT BRASS	BURGESS K15E	2.25 OZ.	EVEREADY 420
	45	2 17/32 x 31/32 x 4 1/32	SOCKET	BURGESS XX30E	6.75 OZ.	
	45	2 17/32 x 31/32 x 3 21/32	SNAPS	BURGESS XX30	8.5 OZ.	EVEREADY 912
ACTUATORS	1½	17/32 DIA. x 1 31/32	BRASS CAP	BURGESS 2	.5 OZ.	EVEREADY 915
	1½	13/16 DIA. x 1 15/16	BRASS CAP	BURGESS 1	1.5 OZ.	EVEREADY 935
	3	1 3/16 x 1 3/4 x 2 13/32	PLUG	BURGESS 222P1	3.3 OZ.	

OTHER MANUFACTURERS GIVE EQUIVALENT TYPE SIZES IN CASE BURGESS BATTERIES ARE NOT AVAILABLE. BATTERY LIFE IS NOT GIVEN DUE TO WIDELY VARIED USE THEY ARE SUBJECTED TO. ALL BATTERIES LISTED EXCEPT BURGESS 7 AND OLIN 0815 HAVE BEEN BENCH AND FLIGHT TESTED AND WILL GIVE ADEQUATE SERVICE PER WEIGHT.

(1) RECOMMENDED ONLY WHEN WEIGHT AND SPACE ARE PRIME FACTORS
(2) "PENCELL"
(3) "C" SIZE BATTERY
(4) "D" SIZE BATTERY

Wennerstrom

gauge boxes, especially designed for RC work, are available. Special plastic boxes for four pen cells are obtainable. The batteries fit vertically into these boxes. Each box is in two sections, held together by means of a long screw. Convenient flanges make it easy to set the boxes upon bearers cemented to the faces of adjoining bulkheads.

Connections are made in various ways. If boxes are not used, the wires are soldered directly to both A and B batteries, and escapement cells as well. Avoid overheating the batteries with an oversized iron, especially hearing aids. Some batteries have plug-in or strap-on connection features. Secure the strap (snaps on like dress snaps) with tape for safety.

For transmitters, B battery size is limited by the bulk and weight in the hand-held case, but in stationary types the largest possible batteries are recommended for long life. Sufficient space exists in any transmitter for a reasonable size A battery. Reference has already been made to checking batteries under load. When the transmitter keying switch is closed it will be found that B batteries may drop anywhere from a volt or two, to between 5 and 10 volts, depending on the size and age of the batteries. But once the battery hits the minimum voltage under load, as shown on the volt meter, watch to see if it gradually keeps on losing voltage, such as 15 or 20 volts. If so, discard it.

Chapter Five

BATTERIES

Manufacturers' directions always include data on various combinations of batteries that may be used with their equipment. Therefore, we will not survey batteries required for particular receivers and transmitters, but will make some observations helpful in deciding what batteries to choose, as well as a few facts governing battery life and maintenance.

The bigger the battery that can be used, the longer its life, and the less fussing with receiver or transmitter. Bigger batteries are more reliable than small ones, especially on long flights. The smaller, optional battery arrangements should be used only when airplane size and power makes heavier, bigger batteries, impractical.

All the single-channel, straight carrier wave receivers require an A battery, usually of 1½ volts, but 6 to 7½ volts on 465; a B battery, which is 45 to 67½ volts for gas tube receivers, and usually 67½ for hard tubers.

Let's consider the .049 RC design, the smallest you'll ever want to fly. This power is adequate for either a single or two-tube receiver, with two pen cells in parallel for A, and two 22½-volt hearing aids in series for B with gas tubes, or three such batteries or two 30-volt hearing aids, as specified, for hard tubes. The escapement should take two pen cells in series for 3 volts, although English types may require 4½ volts.

Regardless of size of plane, two pen cells in parallel to give 1½ volts will suffice for A supply with single-tube receivers but, when .09 displacement is reached, four pen cells in series-parallel may be used for longer A life. If a .15 or larger engine is used, it makes good sense to switch to medium-sized flashlight cells throughout. Excepting the 465 receiver, it may be desired in bigger planes to increase B battery size, substituting, say, a 67½ volt Burgess K-45, or its equivalent, for three hearing aids, or an XX-30 or equivalent for two 22½-volt

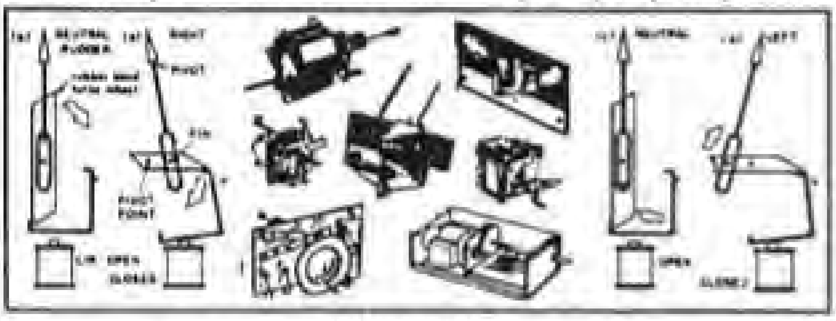
The escapement batteries may be placed under load with most single tube receivers by switching on the escapement and leaving the receiver switched off. The relay thus drops out, closing the contact to operate the escapement. Where a separate escapement switch is not provided, turn on the receiver and transmit a signal to cause the relay to drop out and work the escapement, or carefully move the armature with the finger to make contact. Measure the voltage at the escapement, not at the battery box or pack. There is a voltage loss along the line when lengthy leads separate receiver and escapement.

Some fliers may use batteries for many dozens of flights, whereas others, with the same equipment and batteries, complain about battery replacement costs. Batteries should be allowed to recuperate between flights for at least three to four times the amount of time that they were just in the air. The voltage actually rises during these rest periods.

The maneuverability and adjustment of the plane itself affects battery life in both transmitter and receiver. A slow, gently responding airplane which requires sustained application of rudder, is running down B and escapement batteries all the time control is held on. A fast responding plane reduces the length of time these batteries are under load. In cold weather battery voltage is reduced; never fly in extreme cold with batteries that are even moderately run down. However, the same batteries, when heated, will show higher readings.

Battery life charts should be disregarded as they are unduly optimistic for our purposes. We are not interested in how long a bulb can be kept lit, for example, but in how long the receiver will function reliably. Receiver voltage may be above minimum when the plane takes off but suppose it drops below minimum in the air! Also, when equipment is operated near minimum voltages, performance is reduced; the radio manufacturer really means that the minimum is where the equipment becomes marginal. It is better to allow yourself a safety margin rather than squeeze the last volt out of the batteries. Battery cost, relative to the cost of time and the materials in the plane, to say nothing of the expensive radio, is not important.

New batteries should be purchased from suppliers whose stock moves fast, such as hearing aid establishments who stock virtually any battery size needed for receiver operation—and these are fresh. Many hobby shops carry batteries.



Chapter Six

ACTUATORS

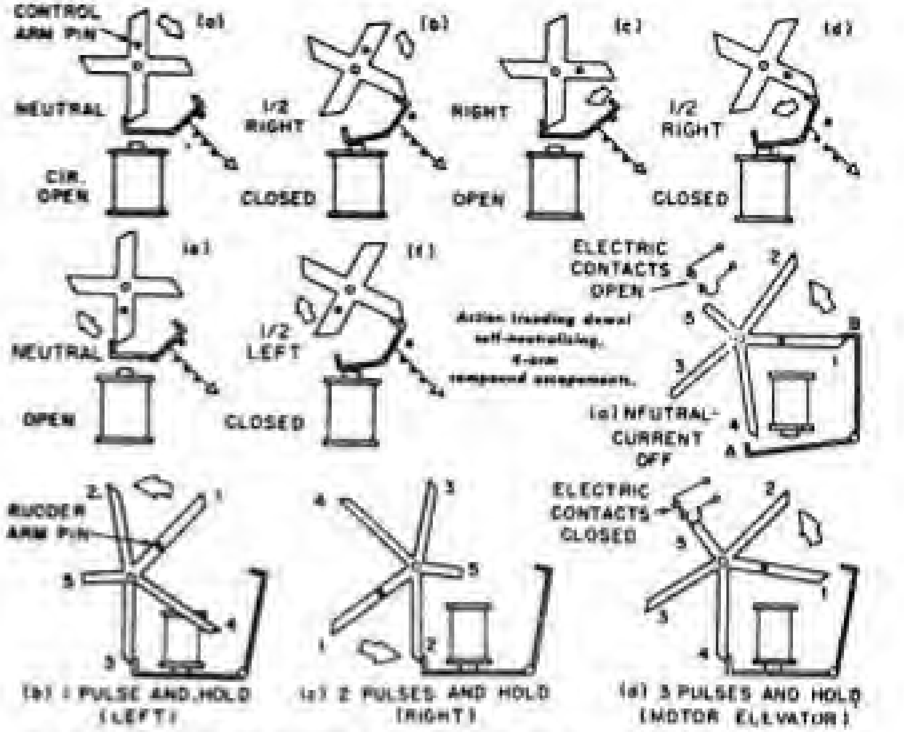
An actuator is a device for moving the rudder, elevators, or other controls. Two basic types of actuator exist: escapements and servos. An escapement is an electro-mechanical device in which a revolving arm, powered by a twisted loop of rubber, is released and allowed to turn either an eighth or a quarter revolution when its magnet is energized. The escapement moves a wire linkage, torsion rod or, by means of a bellcrank, a push rod, which, in turn, moves the control surface.

The servo is an electric motor powered device which, by means of reduction gears, works a push rod for moving control surfaces. Approximately the size of an escapement, perhaps slightly bigger and heavier than the average escapement, the servo applies stronger forces more precisely, as for trimming elevators when multi-channel receivers are used. Although escapements are more widely used, servos now are being manufactured for single-channel as well as multi-channel applications. Current may be supplied to both types of actuator with pen cell batteries.

Although escapements take many forms and shapes there are only three basic types: the two-arm self-neutralizing; the four-arm; and the compound, or single neutral type. The self-neutralizing type assumes a control position on signal, and returns to neutral when the signal terminates. The four-arm assumes a half-way position on signal, then goes to full position when the signal terminates, and does not return to neutral until moved there by an additional signal. The compound selects left or right, or the second control position, depending on the number of signals (one to three) transmitted. It remains on the selected position as long as the final pulsed signal is held, and always returns to the same neutral when the signal terminates.

Starting from neutral, the sequence for the two-arm escapement is as follows: neutral, right (or left), neutral, left (or right). For the four-arm it is: neutral, half right, full right, half right, neutral, half left, full left, half left, neutral. It, too, may be started for left rudder first, depending on what had been the last movement. The compound has no sequence, always giving the same control for the same number of pulses. When the compound is in the extra control position, it does not turn the airplane, but closes electrical contacts completing a circuit to a second escapement—which may be either two or four-arm, or a relay, or a servo or other device.

Ascertain the resistance in ohms of your escapement. This generally varies from five to about twelve ohms, with an average of about six or seven. The more or the higher the ohms, the less will be the battery drain. Low ohm escapements run down batteries more quickly, although battery drain is not a problem with



any escapement on the market. But with the high-ohm escapement you can use smaller batteries or get by for longer with the usual batteries.

Do not use more voltage than called for by the manufacturer. If the directions say 3 volts, use 3 volts; if 4½, use 4½. Extra voltage raises cain with some escapements. Residual magnetism is one common result, which causes malfunctioning of the escapement. This form of magnetism builds up with rapid use of the device, as when pulsing quickly. When the escapement is allowed to stand, the residual magnetism may disappear, making troubleshooting hopeless.

Examine new escapements under a magnifying glass, checking for rough edges, burrs, paint droplets, etc., that interfere with the arm's sliding free of the claw edge or altering the critical gaps. Do not file the revolving arm or pawl, as the faces may get out of alinement or the arm become too short for reliable operation. Do dress the surface of the claw end, if necessary, with a fine stone. When a burr develops, as it frequently does with service, engine vibration assists the escapement to work, but it may "hang up" during the glide for a loss of control.

Any good escapement will allow use of either 1/8 or 3/16 inch rubber. If skipping occurs and there is some doubt about the escapement, reduce the size of the rubber or place less turns upon it. This is particularly true of home made escapements. When using heavier rubber and many windings, more frequent inspection of the escapement is necessary because burrs develop more easily from the greater impact.

An essential part of the escapement system is the linkage which connects it to the control surface. Sloppy workmanship, poor design, and inadequate maintenance contribute to poor control. For instance, a long, too-thin wire torsion bar may twist so that required rudder movement does not result in the air, or, at high speed, the amount of rudder movement may be cut down.

Allow extra clearance between yokes and pins so that the pin doesn't jam within the yoke when the rudder is in the full over position. Where the linkage passes through a bushing make the bushing inside diameter a trifle larger so that rust or roughness on the wire doesn't induce friction that slows down or retards escapement action to the point of skipping or jamming. Use powdered graphite, not oil for lubrication.

Avoid excessively long yokes at the end of torsion rods because vibration may shake them hard enough to interfere with escapement action. Inertia of the long yokes may cause the revolving arm to bounce off the pawl, then to slide on by to the next rudder position. This is especially true when two yokes are bent in the same direction: the mass of the linkage is then so far off center that erratic action easily results.

Because the self-neutralizing type of escapement gives an all or nothing position to the rudder, that surface being either all the way over, or in neutral, it is generally necessary to make repeated applications of control in the one direction in order to complete a turn. If the rudder was held over continuously, the nose of the plane would drop and enter a spiral or, in the case of a good aerobatic machine, a split-S might result. A really powerful, maneuverable rudder-only job might even do a straight line roll.

Suppose, for example, that the next rudder position is right. As right rudder is applied and the plane begins to overbank and drop the nose, the operator releases the signal, allowing the escapement to return to neutral, but he instantly applies opposite, or left rudder, relaxing that signal before the airplane can respond, and then applies, and holds momentarily, right rudder. This process may have to be repeated several times to complete a 360° turn. Fliers call this technique "double blipping." With practice it can be done instinctively, quickly. There's a handy rule: "If you don't want the turn you have, give it one signal; if you want more of the same thing, give it two."

This, incidentally, is why some hobbyists are working on proportionate rudder control via various pulsing systems. However, possible to trim a properly designed plane maintains a perfectly banked turn once that turn has been begun: it's a matter of dihedral, and center of gravity position, more than anything else.

When used with a pulsing system, a magnetic actuator does provide proportionate rudder control in either direction. However, while this system allows more precise maneuvering on rudder, it adds more gadgetry and things to go wrong. It is necessary to have an electric motor driven, or electronic, pulsing device attached to the transmitter. This gadget, usually about as big as a small size cigar box, replaces the keying lead switch. The mechanical pulser consists of a revolving drum and a control stick whose inner end slides along the drum, making contact, when moved right or left. The surface of the drum at one end is entirely metallic; at the other end it is entirely of wood. At the neutral point, or midway position, where the stick is held for neutral, the surface of the drum presents an evenly spaced alternating wood and metal surface as it revolves.

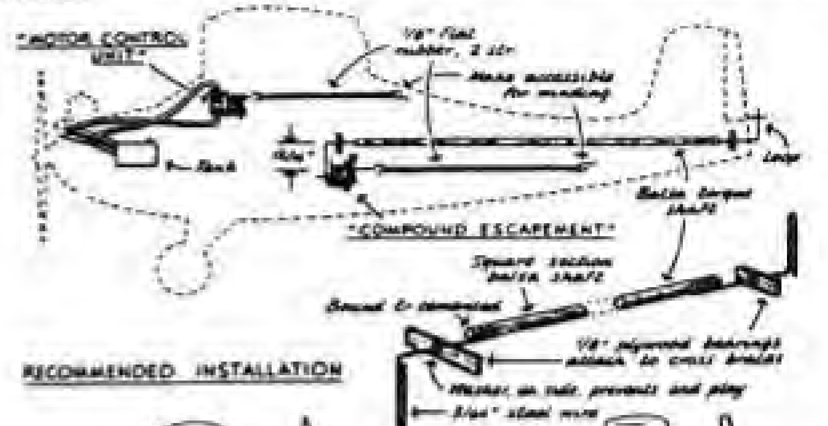
Each time the stick passes over the metal surface of the drum a signal is transmitted. The length of the signal obviously depends on the length of time the stick rests upon metal, or the percentage of metal on the circumference of the drum at the point where the stick makes contact. Thus, this is a pulse length system. At the one end of the drum, no signal would be sent; at the other end, a continuous signal would result. In neutral, the on-offs are of equal length, the rudder wiggles back and forth in response, but moves too fast for the airplane to obey and straight flight results.

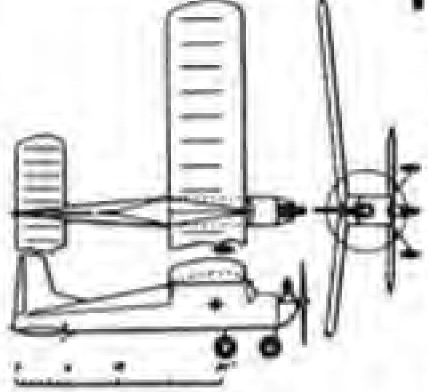
The magnetic actuator in the airplane is connected to the relay in such a way that, if the relay drops out, it moves in one direction, turning the rudder an equal amount. If the relay pulls-in, the actuator moves in the opposite direction. As the ground controller stick is moved to one side of the drum or the other, the relay in the plane tends to remain longer in the corresponding position. It is either pulled in most of the time, or dropped out most of the time, depending. The rudder, therefore, will tend to remain longer to one side imparting the exact degree of turn desired by the pilot.

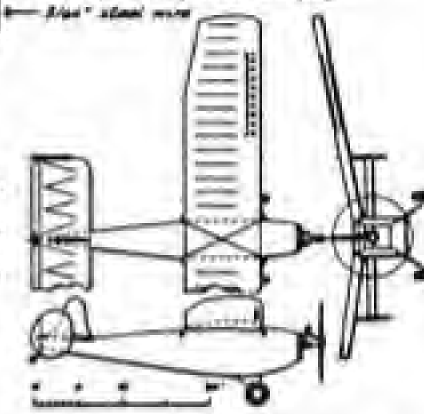
One drawback of the system is that a failure of any type, including flying out of range, results in a spin-in. The ingenious reader can devise a failure-proof system working from additional contacts that close if and when the rudder goes full over.

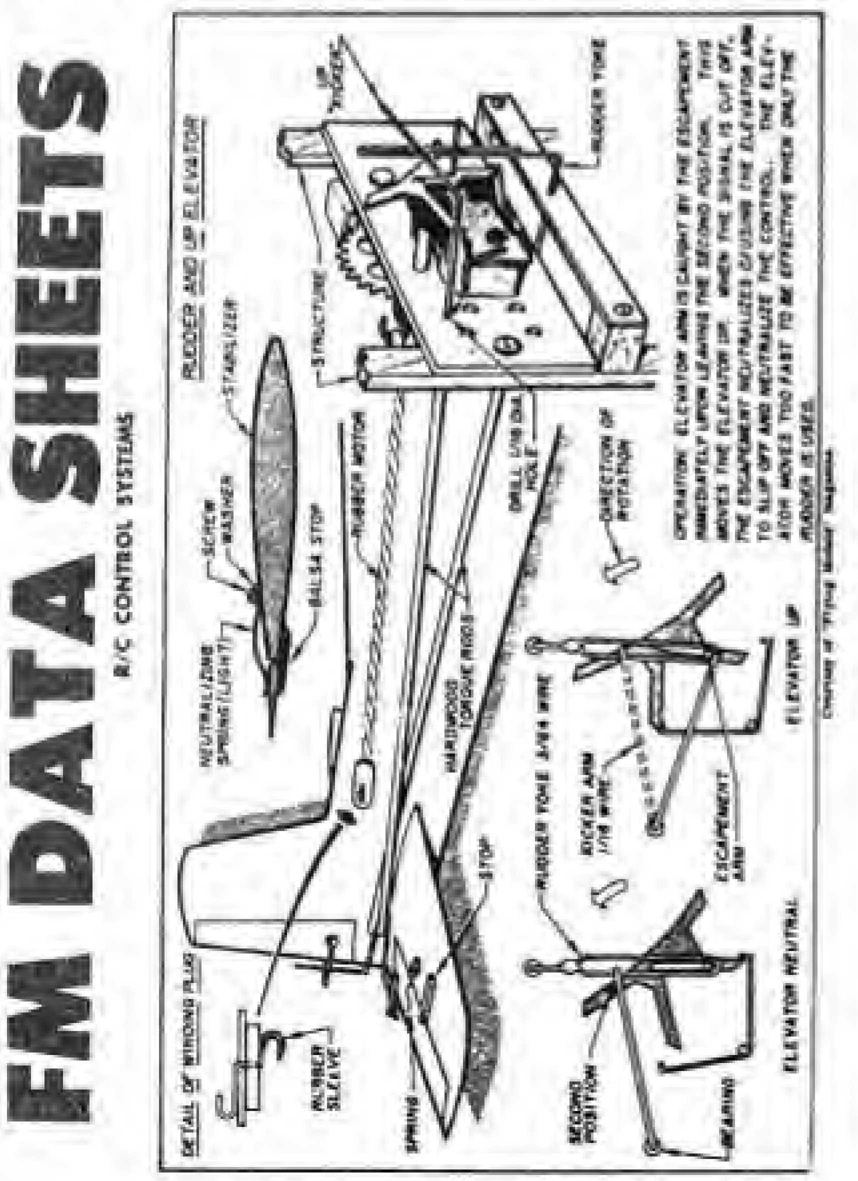
All manner of control switches and "beep boxes" have been devised, either to provide additional controls or to remove confusion when using any sequence escapement. The typical beep box is a variation of the revolving drum pulser, however, instead of a variable metallic surface, the drum is entirely of wood or some other non-conducting material, and has, jutting up from its surface, strategically placed pins or stops. Movements of the control stick engage the proper stops, and, during the brief interval of time consumed in moving from one stop to another, a contact arrangement at one end of the drum sends out the selected number of signals. A slipping clutch system allows the drum to resume speed as soon as the stick disengages the last stop.

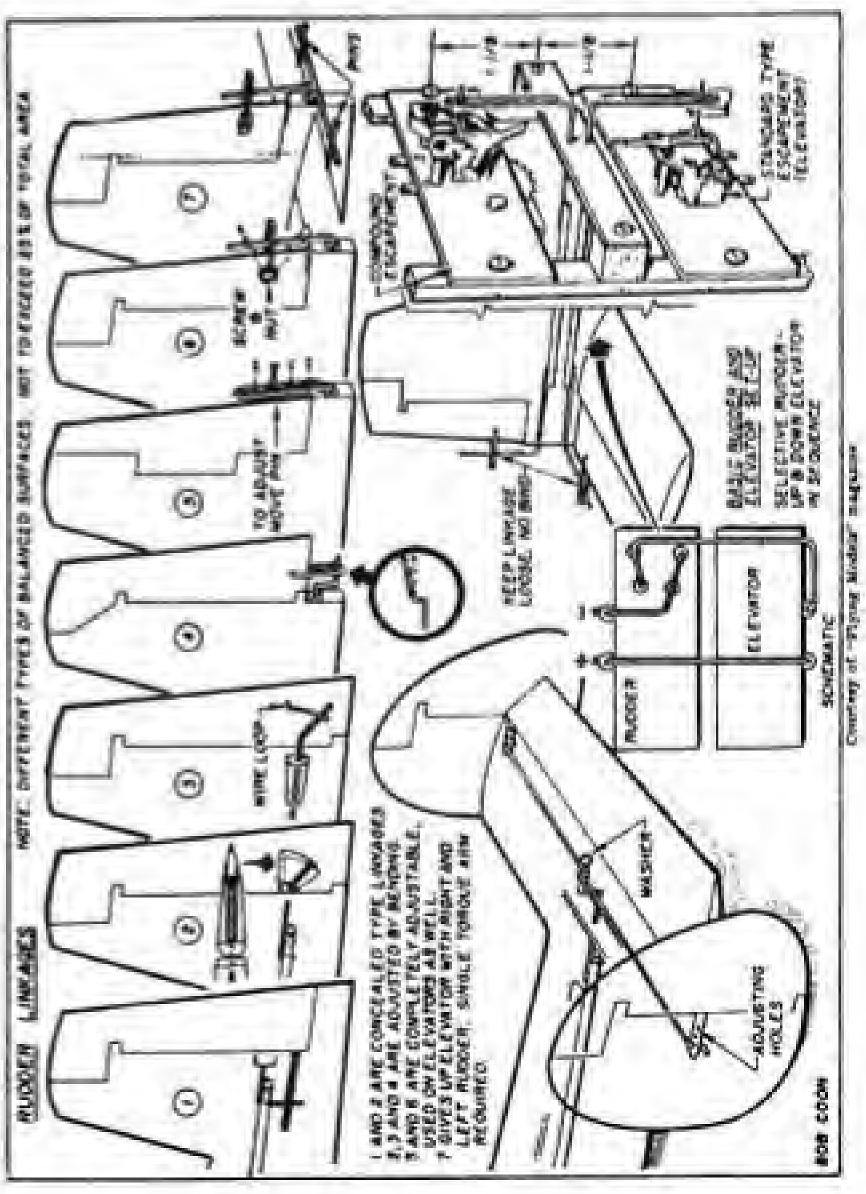
When considering such systems, or multi-controls of any kind, do not write off the single-channel receiver and rudder-only control without trial. Rudder-only is a thoroughly satisfying way to fly and it takes a top notch pilot, even with the most expensive equipment, to beat out a capable rudder-only man at a contest.

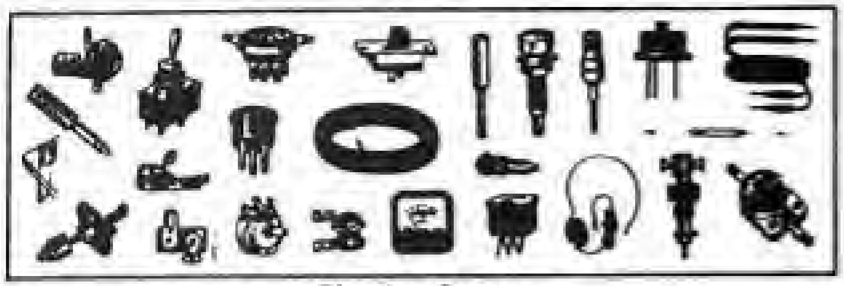












Chapter Seven

INSTALLATIONS

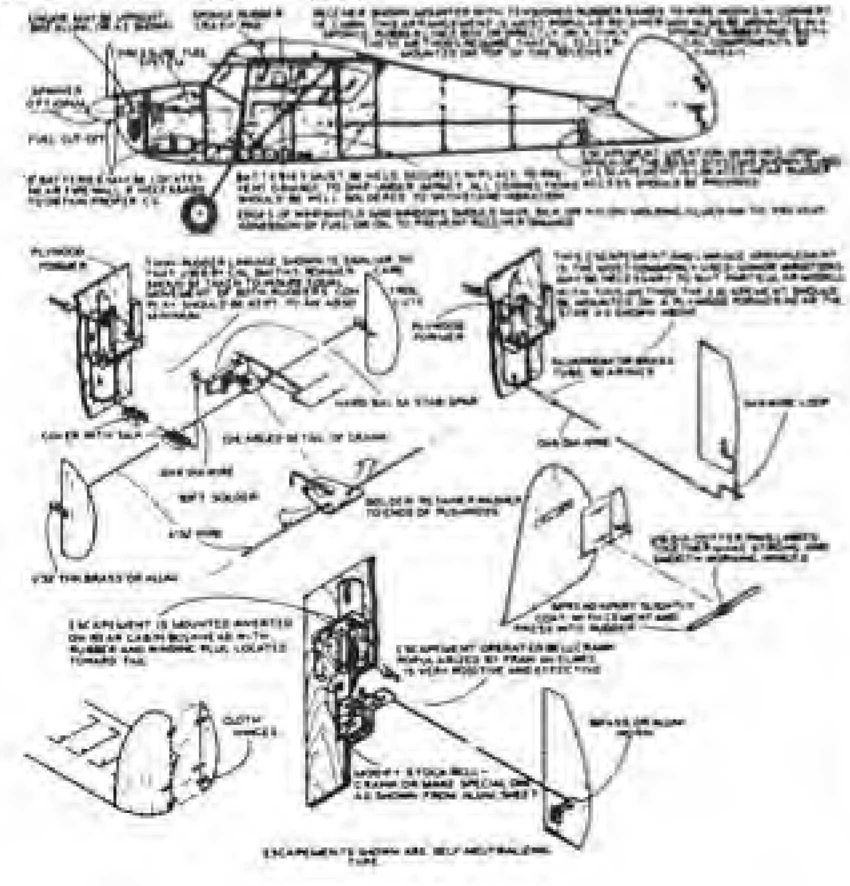
The installation of the receiver, batteries, and escapement in an airplane should provide protection to the receiver, protection to the airplane from the batteries and receiver in a crack-up, and accessibility to the receiver for tuning and to the batteries for checking and replacement. The escapement and its rubber should be accessible for servicing. The secret of a good installation is to know where everything has to go before the airplane is finished. The plane should be designed around the radio equipment.

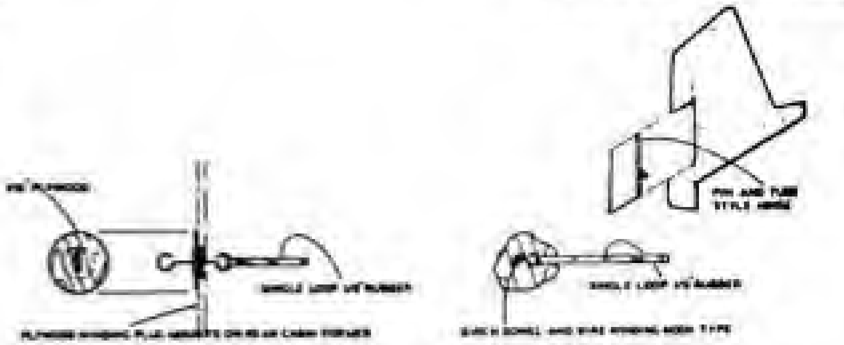
Beginning point is a cabin spacious enough to allow easy installation and removal of the receiver and of the batteries and escapement, if those units happen to be within the cabin proper. Receivers usually are mounted by two methods: suspended from rubberbands attached to hooks on the cabin walls, or on foam rubber, preferably attached to a sliding tray of plywood which fits against the front bulkhead of the cabin. The latter is the superior method because it is quickly removable and highly crash resistant. To prevent a rubberband suspended receiver from shooting back and forth in the cabin when the plane strikes an obstacle, a tether cord is tied between the rear of the chassis and some solidly mounted structural part, like the rear wing hold-down dowels. Leave only slight slack in the cord. In either method of mounting, be sure that the receiver cannot bang against potentiometers, jacks, or other objects sticking out from the cabin walls.

Wire leads are attached by two methods to the receiver: to fahnstock clips at the corners of the chassis (which also hold the rubber suspension bands), or as a cable terminated in a plug, the socket for which is permanently mounted in a special plywood partition, bulkhead, etc. Wires from the batteries terminate on the underside of the socket. Coat the underside of the socket with cement to prevent vibration from breaking off the soldering tabs.

Batteries may be mounted in taped-together packs in a snug fitting compartment (constructed before the fuselage is covered), with a convenient hatch either on top of the nose, under the nose, or under the cabin. The proper center of gravity position usually demands that these batteries be located forward of the leading edge. The structure should be tied together designwise so that batteries cannot knock loose the adjacent bulkhead, nor should that bulkhead be easily split. This bulkhead should be supported at the ends and in the middle. Plywood simplifies the problem.

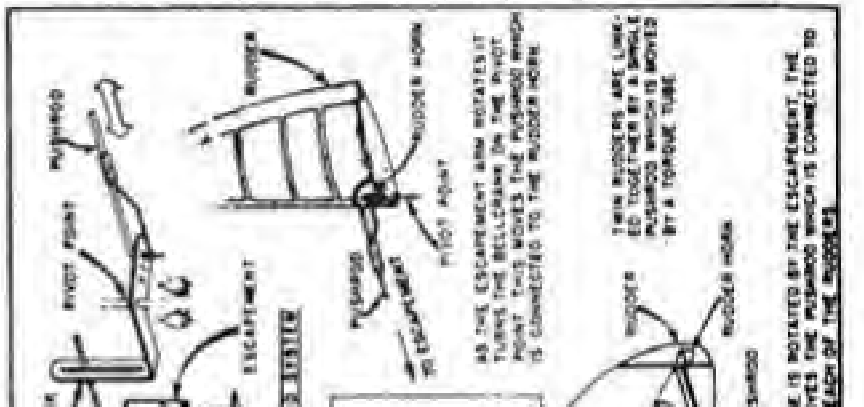
Battery boxes must be accessible. The plastic type with vertical mounting may be reached easily from the top of the nose. On larger planes metal boxes may be installed in the nose or, if space is cramped, underneath the cabin floor, with a large removable hatch forming the bottom of the fuselage at that point. The floor should be plywood; 1/8 ply should be adequate for the largest of planes.





Batteries should not be located inside the cabin in such a manner that the receiver must be moved to replace them. If batteries must go inside the cabin, plan some practical arrangement.

On small planes the weight of an escapement at the rear makes proper trimming difficult; on larger planes the rear-mounted escapement requires long leads with a possible loss of battery voltage along the line. For such reasons it is desirable to mount the escapement at the rear of the cabin, accessible through the open top of the fuselage. Since an escapement should be examined periodically, it is advisable to place it on a plywood slide. Arrange convenient means for replacing and winding escapement rubber. Avoid S hooks on the escapement shaft as the hook may climb the shaft and cause jamming.



With the forward-mounted escapement, the linkage may be lengthened as necessary by means of a balsa strip or metal tubing, to the ends of which are attached the yokes. Or, if a bellcrank is employed with a push rod, the crank is attached solidly to the cabin floor. The shape of the manufactured RC bellcranks suggests obvious arrangements. Servos, of course, always are mounted within the cabin, close to the center of gravity, because of their greater weight. Magnetic actuators should be installed well forward.

Although the bellcrank arrangement is suitable for normal use, the torsion rod is more easily moved and places no dead weight upon the escapement. When the plane is in a nose-down position, the escapement must lift the weight of the push rod. With elevators, the weight of the push rod, plus the weight of the surfaces when deflected, places heavy additional loads on the escapement which could fail or falter in a crucial position. Such additional loads transmitted to the escapement mean that it will have higher pull-in voltage; if, ordinarily, it pulls in at 2 volts it might not pull in at less than, say, 2¾ volts, when handicapped by a poorly designed control system.

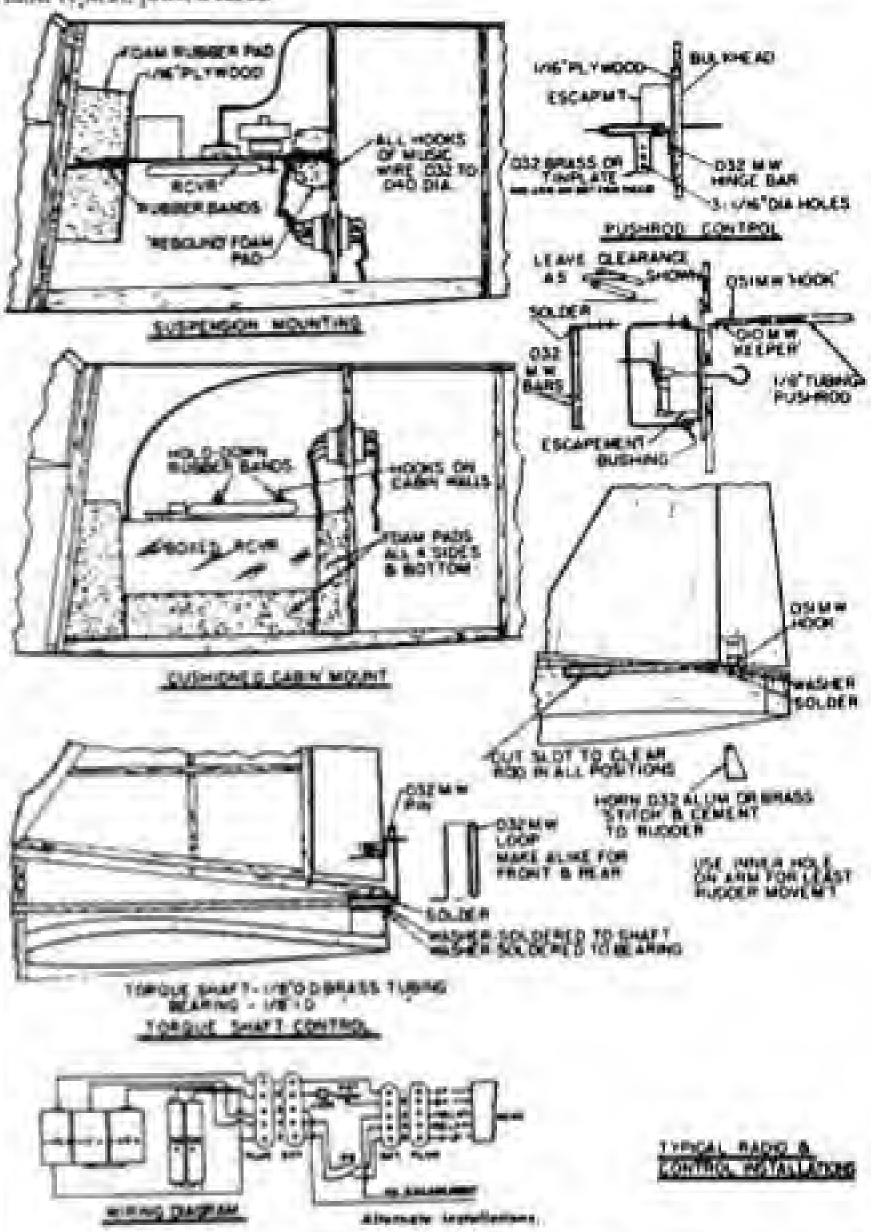
Potentiometers, phone jacks, and switches also should be conveniently located, out of the way for launching (sometimes switches are accidentally flipped off during launching), and out of the way, inside the plane, for the receiver when it is bounced about by rough landings. Usually, those parts may be grouped together, perhaps in a line. The cabin wall, at the point of installation, should be reinforced with a piece of 1/16 inch thick plywood. The location of these parts varies, but most commonly is at the left of the fuselage, readily available to the launcher. Sometimes switches jut out from the fuselage bottom or from the fuselage top, back of the wing.

The milliammeter should be attached directly to the phono plug, because long leads may affect tuning. The meter can then be inserted into the phono jack during ground checks without having to hold it with the free hand, or to place the plane upon the ground because you don't have three arms. Sometimes it is desirable to slip a meter into the circuit with the engine running to help isolate trouble; therefore, place the jack so that the meter can be used without taking off a wing. If two jacks are used with a two-tube receiver, position them so that two meters may be used simultaneously if desired.

Wiring inside the plane should not run loosely from point to point, but should be brought along, and fastened to, the fuselage sides or bottom so that it does not shift about with odd effects upon the receiver. Loose wiring is vulnerable to vibration. With either battery boxes or packs it will be found that wires can be grouped together, separating only for attachment to the receiver or to the socket into which the receiver cable plugs. Individual wires may be held down by cut-off pieces of pins, bent U-shaped, and forced into the wood like staples, and finally cemented. Don't make rigid wire connections anywhere, but allow enough slack to make a small pigtail to absorb vibration. This is particularly important where wires attach to switches or enter battery boxes. Use toggle switches rather than slide types.

For the flier with more than one airplane it is a good idea to standardize installations, so that one receiver may be shifted from plane to plane. A receiver cable with plug and socket is ideal, and the receiver mounted upon a slide is most easily interchanged. If cabin interiors are held to a standard dimension, a balsa box can be built to hold the receiver, the escapement or servo, and perhaps the batteries with all the wiring. Switches, etc., would be mounted on the box and protruding parts, such as switch handles, could be dropped through holes cut in the airplane skin. The meter jack could be inserted through a hole to reach the box.

The bigger, heavier, multi-channel receivers should be mounted in accordance with the manufacturer's directions. Shock mounting these heavier, bigger units must be carefully worked out to prevent the receiver from breaking loose, and the manufacturer of such equipment has found the best means of doing so. But where simpler radios are concerned, all kinds of gimmicks have been developed by the modelers themselves. The above description represents the most typical, proven ideas.



TYPICAL RADIO & CONTROL INSTALLATIONS

Chapter Eight
THE AIRPLANE

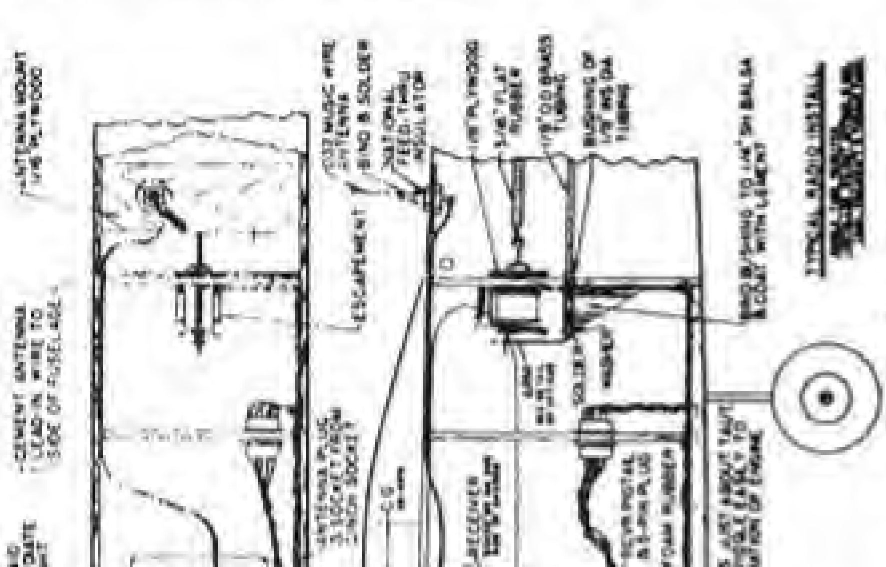
The RC airplane is as much a special design as a U-control stunter, speed model, or contest free flight. It once was considered necessary to have a high powered monster of eight or ten-foot wing span for RC, with a gross weight running as high as fifteen pounds. Its "crew" would spend most of the day tinkering with its innards and then usually crack-up along about sunset. The builder was satisfied merely to see it fly. No special attention was given to how it flew, or to the flight characteristics it should possess.

The modern RC job spans anywhere from thirty inches to six feet, though a few people always will want them big! Half-A engines are practical. A .15 to .19 engine will carry anything required, and .29's to .35's will stunt the heaviest multi-channeled receiver on the market.

The newcomer to RC has misconceptions about "low power." If a U-control stunt model weighing thirty ounces is powered by a Fox .35, he reasons, how can this loaded-down RC job be expected to fly with half the power? Actually, the RC ship is trimmed to fly-flat, does not hang like a free flight, so that most of its thrust is devoted to pulling the airplane and not to lifting its dead weight vertically. A .29 in a lightly built five-foot RC job will separate the men from the boys.

At high forward speeds, control applications result in abrupt, breathtaking maneuvers. The writer has had machines which would fly inverted at 400-ounce power loading (weight in ounces divided by displacement in cubic inches); 375 ounces is a good all around figure. With a good engine and correct propeller, a plane would barely fly at 700-ounce power loading, but this is another extreme. Excess power results in very high climb, risk of loss, excessive altitudes, and the necessity of frequent spin-downs to kill that altitude, with attendant violent recoveries and zooms which may result in the airplane getting out of hand. In a wind, high power is poison.

The RC ship should not be needlessly heavy, or, on the other hand, a "floater." Good flight characteristics result from wing loadings between fourteen and eighteen ounces per square foot of wing area. These power and wing loading figures are valid for .09 to .15 engines, may be lower with smaller ships, or higher with bigger jobs. The various kits available from your dealer will fall within these limits when fitted with radio and loaded down with batteries. A rough estimate of span by classes of engines: .049–36 to 40 in.; .09–40 to 50 in.; .15–54 to 60 in.; .19–54 to 72 in. plus; .29, .32, .35 etc.–60 to 84 in. The beginner should work with the more moderate figures in all cases.



Typical installation.

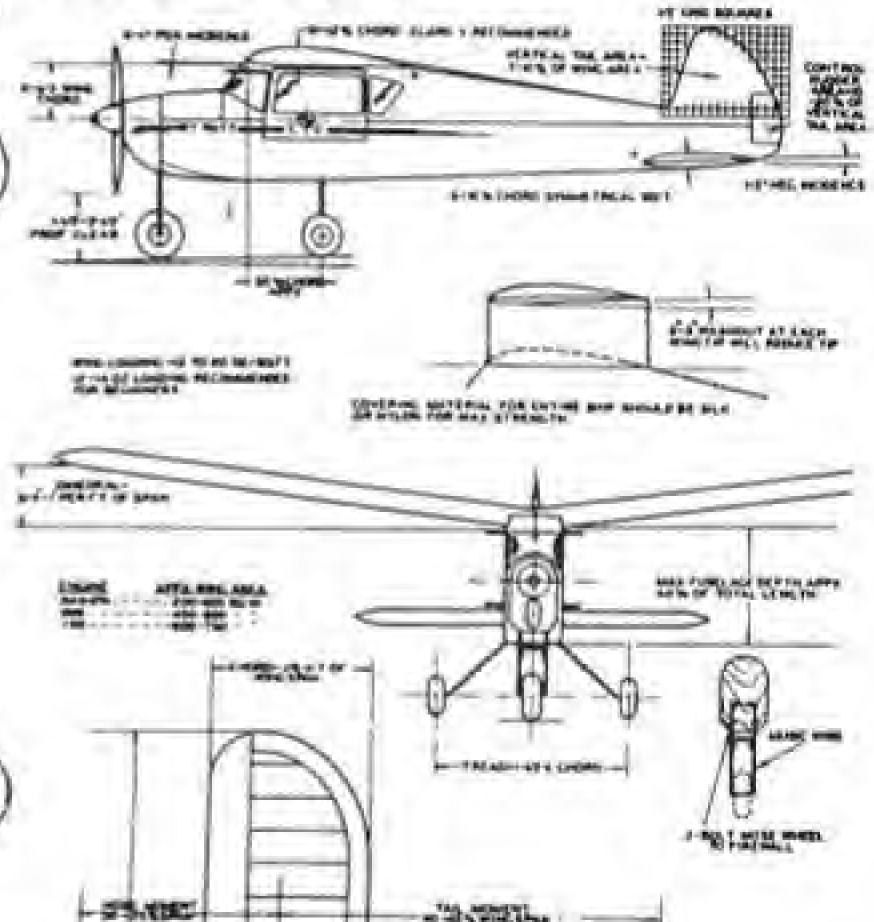
If you design your own machines, some knowledge of latest trends and proportions will be helpful. Aspect ratio, or the relation of the span to the chord, or width of the wing, is low when compared with free flight, ranging from 5½ to 1, to 6 to 1. The tail moment arm, roughly the distance between the centers of the wing and stabilizer chords, need not be longer than 40 per cent of the span. Stuntable designs are becoming shorter and shorter, with as little as two chord lengths of distance between the trailing edge of the wing and the leading edge of the stabilizer. Nose lengths, on the other hand, are becoming longer. A distance equal to about seventy five per cent of the wing chord, between rear prop washer and leading edge, is a good minimum. It is always a problem to get an RC plane nose-heavy enough when properly trimmed.

Both straight and polyhedral wings are employed. An excessive amount of either gives rough turn entries and an abrupt rocking-out recovery as soon as the signal is stopped. Too little of either, and the plane has a tendency to stay in the turn, to develop spiral dives, unless the overbanking is prevented by use of opposite rudder. Measured on straight dihedral, an angle of approximately 6-7° gives best all around performance.

Wing and stabilizer settings are important for stability, resistance to stall build-ups, and quick recovery. With a symmetrical cross-section stabilizer, the angular difference should be at least 1½° and not more than 3°. With a lifting type stabilizer, this angular difference should never be less than 3° because, in spirals, dives and other maneuvers where air speed builds up, the stabilizer may develop more lift in proportion to the wing and dive the ship into the ground. For the same reason, it is dangerous to increase the positive incidence in the tail by means of shims. Once the angular difference becomes too small the plane has poor stall resistance, may roller coaster in the wind, or dive in from a spiral.

Virtually all RC planes require varying amounts of right and downthrust. This probably averages out to about 2° right, and 5° down. Some airplanes have both wing and tail set at a positive angle so that, while the thrust line appears parallel to the ground in the take-off position, there is actually a built-in, though invisible, downthrust. Downthrust will make the plane fly faster through its effect on trim. It is imperative on slow gliding planes that seek to fly appreciably faster under power.

Two basic systems of trimming are practiced; your choice determines what you do to the fuselage during construction. With either system, the center of gravity, or CG, should be well forward, anywhere from thirty to forty per cent of the chord back of the leading edge. (Placing the CG farther to the rear invites trouble.) The resulting nose-heavy glide is compensated for by increasing the angular difference, usually by increasing the amount of negative incidence of the stabilizer. In the first system the wing is placed flat upon the fuselage top which should be parallel to the ground line. The stabilizer is then set with its leading edge at a negative angle of ½ to 1½°.

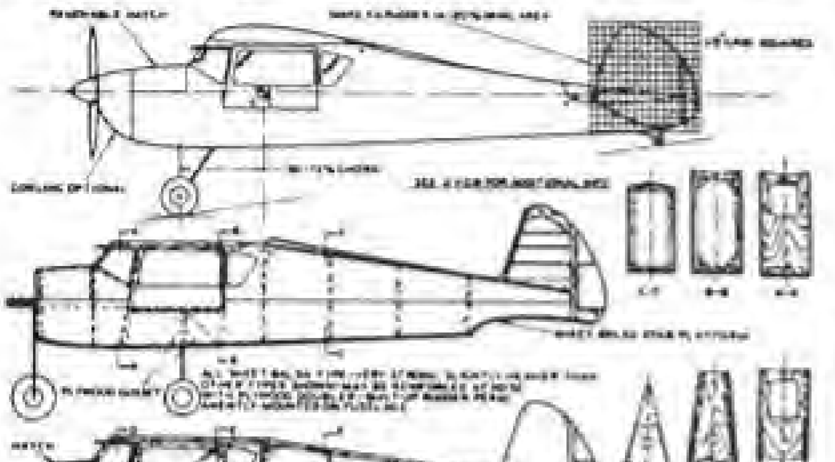


Typical proportions.

The second system involves placing both wing and stabilizer at a positive angle to a line parallel to the ground line, as much as five to 8° for the wing, and 3½ to 7½° for the tail, or some other amount depending on the necessary angular difference. This system removes unsightly downthrust as far as the eye is concerned, and tends to give a buoyant airplane in maneuvers, one that "pops" well for loops. The first system may result in a highly responsive ship on rudder and high wind penetration. Its looping ability may be reduced somewhat and downthrust is apparent to the eye.

Both tricycle and two-wheel landing gears are widely used. The former makes the surer take-offs and protects propellers better on rough fields. The latter is lighter, easier and cheaper to construct, and will take off, provided the gear is placed far enough to the rear.

Multi-control planes have begun a trend toward symmetrical wing sections, à la U-control stunters, and short coupled fuselages. Such machines will perform outside loops as easily as the inside variety and will remain on their backs more readily than those using such airfoils as the Clark Y. The symmetrical section



Fuselage construction

cuts down ballooning out of turns, or zooming in a wind gust, and permits much lighter wing loadings (added area for better stunts) without ill effects on the flying characteristics of the plane. They may require a more forward CG position and, possibly, a small angular difference of ½ or 1°. With a rearward CG or large angular difference, they tend to whip into true spins when stalled. It has been found that the wedge type leading edge spoiler is superior to washout for preventing wing tip stalling. When the plane is inverted, washout becomes washin and a wing up will stall, rolling the airplane upright. Six-inch long spoilers are adequate for a 3 1/2 foot machine, with others in proportion.

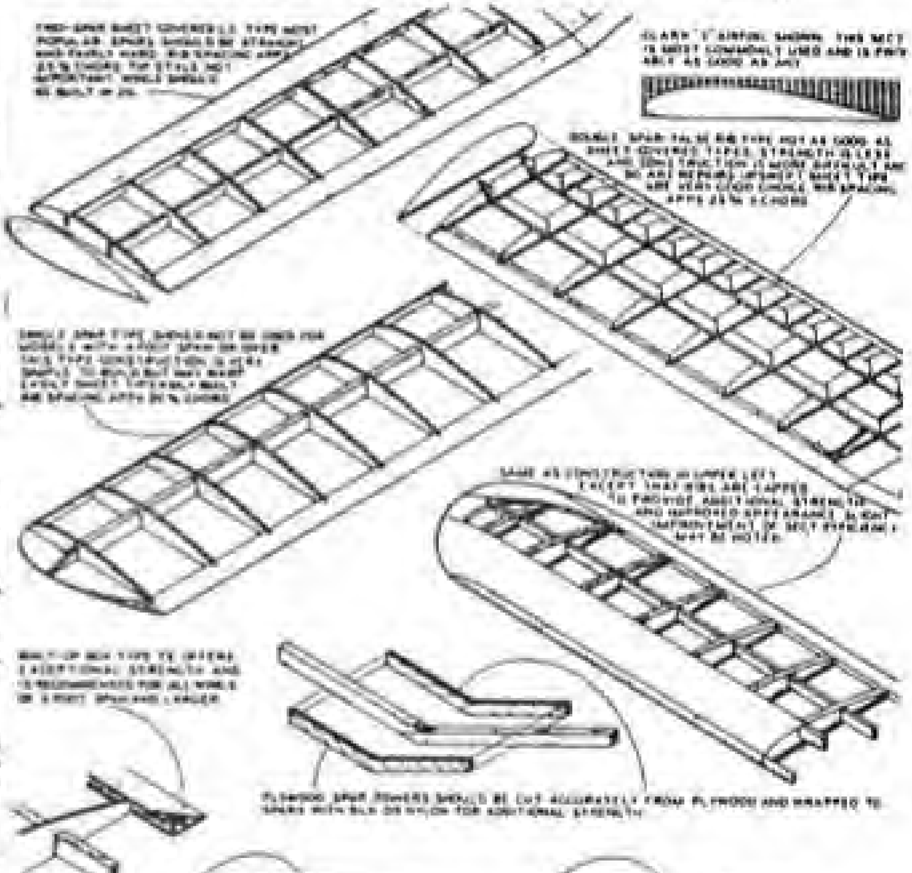
If structural design is good, a radio model will not break up even in a bad crash, unless it strikes cement or hard earth. Fuselage construction may consist of longerons and cross pieces, or of sheet balsa siding and bulkheads. The method used is up to you. If longerons, the wood should be very hard, and the forward sections of the fuselage should be filled in with sheet balsa of the same thickness. A thin facing of plywood inside the fuselage at the nose will increase strength enormously. Sheet balsa fuselages may be laminated at the nose from various thicknesses of material, sanded to match the top view contours. If one or more thicknesses end at a bulkhead station, that bulkhead may be cemented to the butt ends of the side plies, and it will then resist any forward displacement, as from battery impact.

If the material does not have to be curved, as seen on the top view, it will take much higher impact loads. Probably the strongest nose construction results from the use of light balsa blocks, carved and sanded to the proper outlines and cross-sections. Motor mounts and bulkheads that stand in the way of batteries should be anchored and reinforced. Fibreglass nose covering is becoming popular. Fibreglass patching kits may be obtained at boat supply houses and some hobby shops. The fibreglass is attached with a special resin which hardens within an hour of application. The resulting surface is impervious to hard knocks.

Most troubles resulting from wing construction come from warps. Warps create endless difficulties in adjusting and flying and must be removed. Silk and nylon coverings exert a powerful pull when drying, and may continue to pull tighter and tighter for some weeks after completion of the job. A wing or stabilizer may pick up a warp when standing in the hot sun.

Almost any wing can be given warp resistance by the addition of a top spar fairly close to the trailing edge. It is the rear corner of the wing that tends to pull up: this tendency is acute on a single spar wing. Geodetic construction, à la the Hogan type of free flight, would be excellent on radio jobs. Watch the wing panels when the first coat of dope is drying. Counter any warps as they begin to appear by holding the still-wet frame in the correct position until it is dry. Dope a half wing at a time so your attention won't be divided. Thin the dope if it appears unduly thick. Add about six drops of castor oil to the ounce of dope for the last coat or two. This prevents excessive pulling.

To remove warps in a finished wing, hold the panel over a steam kettle or other safe source of heat and, while the wing is hot, twist it in the opposite direction to the warp. Create a warp in the opposite direction as the original warping tendency will cancel it out. Or the wing may be placed flat on the bench; wipe the upper surface lightly and quickly with a rag wet with thinner. This will soften the finish. Hold the wing true until dry.



Wing and tail construction

A common weak point in RC wing design is the leading edge; if too light, it will break on striking bushes, posts, and other objects. Leading edge sheeting is very difficult to repair after this type of failure. False ribs, or half ribs, placed between the full ribs, instead of leading edge sheeting, contribute to leading edge strength.

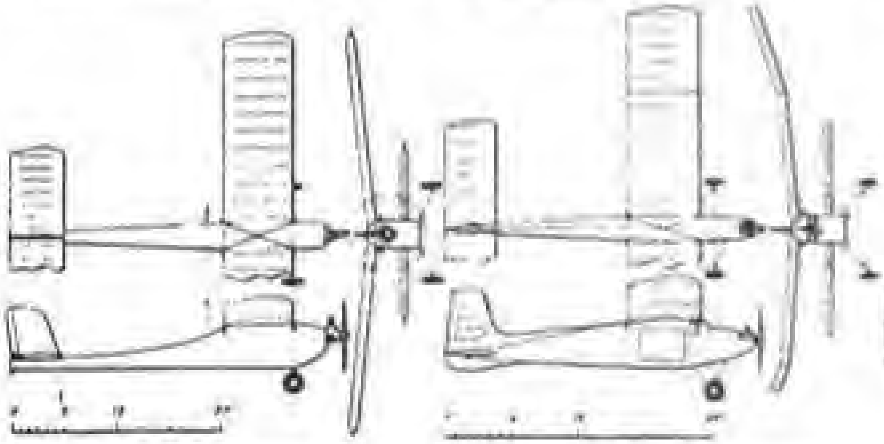
Although spar positions vary greatly, probably the ideal position is through the center of the rib, rather than on top or bottom. If the wing is cloth covered, the bottom surface is then in tension when the plane loops. Such spars will carry a surprising load and are well worth the added work. Also, these locations oppose any tendency of the wing to bow upward from the pull of drying dope.

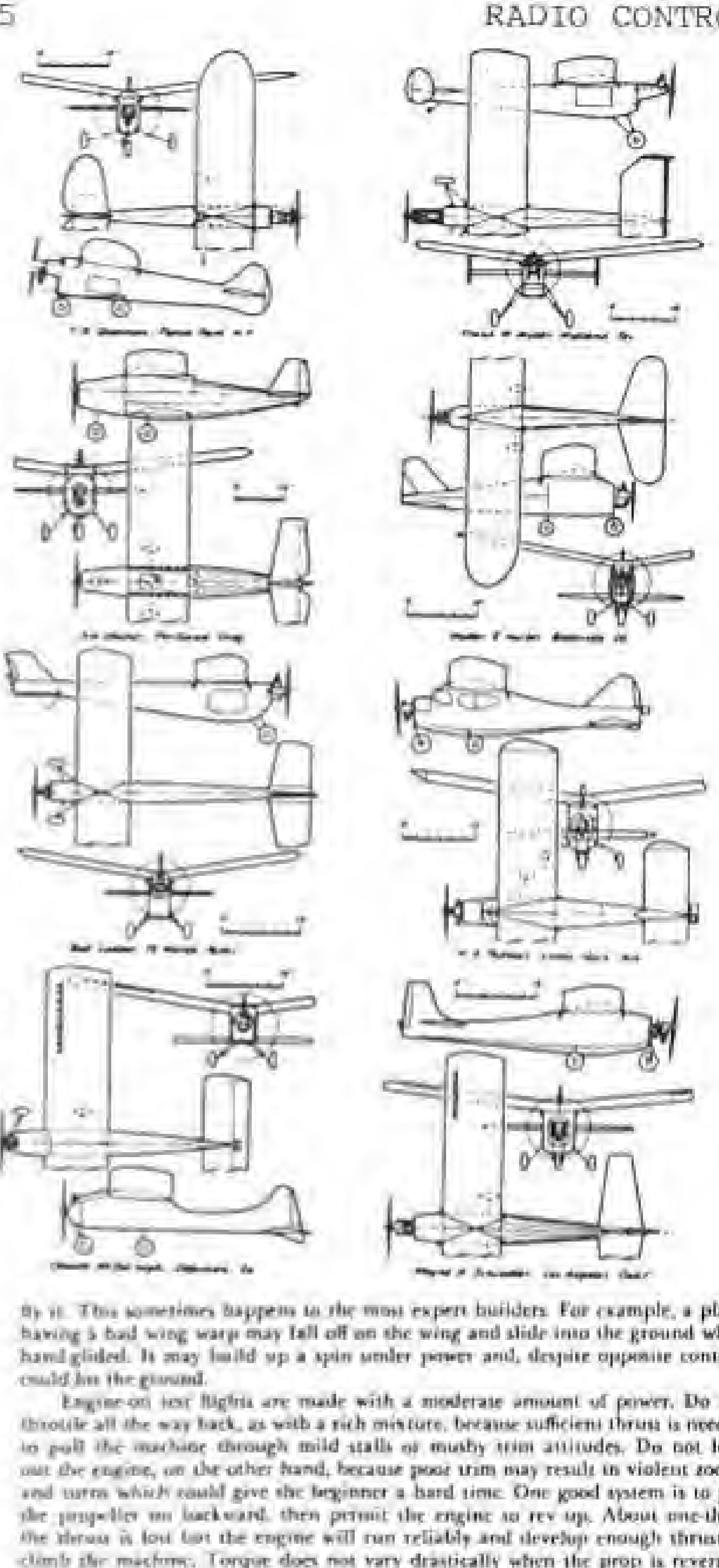
Since it is difficult to keep the rear end of the plane light enough, it is advisable to make the tail surfaces as light as possible and yet maintain warp free construction. Don't add extra material near the tail of the fuselage. Knock off stabilizers seem to have little advantage over those permanently installed. When the plane cartwheels or snags a stabilizer tip, the rubber hold-on bands may break up the rear tip of the body. With knock off tails, the adjoining portion of the fuselage should be reinforced with another thickness of material, and the rear dowel secured against a sideways pull. The integral stabilizer places extra stress upon the fuselage when the plane hits on the nose, as when falling from a tree. But a well-built fuselage takes this punishment. It is essential that the vertical tail be aligned accurately and securely. The fin should be part of the structure of the airplane. If the fin is added after the fuselage is completed, make arrangements beforehand for its accurate placement. A fuselage that is pulled together carelessly at the rear may throw the fin out of alignment. Lay the fuselage on its side during assembly, measure from the table top to the rudder post, then turn the fuselage over and repeat the measurement. Or, measured this way, the rudder post should be off the table a distance equal to one half the fuselage width.

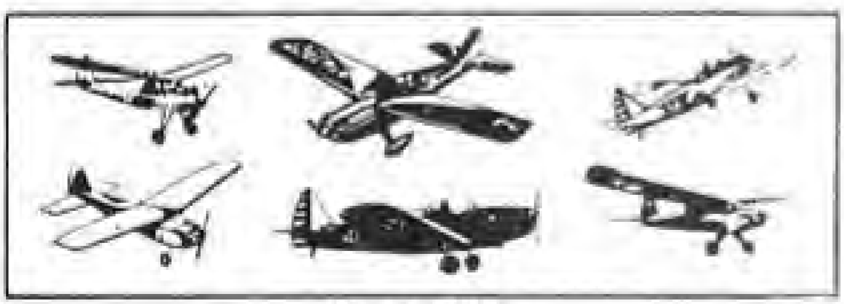
For long life, every joint on an RC model should be double cemented. That is, coat the surfaces to be mated with cement, allow to dry, then recement and press together.

Small airplanes with Half-A engines, and even some .09 jobs, may use sheet balsa stabilizers in lieu of the built-up variety. The wood should be selected for resistance to easy bending, yet not be excessively prone to split. It should be treated when finished with thinned dope plasticized with castor oil, eight drops to the ounce. Vertical fins may be made from a single thickness of balsa up to the larger size models, where thinner balsa sheeting is bent over a spar and ribs. Or, on bigger machines, built-up spar-and-rib vertical tail frames may be covered with paper or fabric.

When simple receivers are used, the tendency is to build the airplane needlessly light. But the contrary is true with complex, heavy radio equipment. Then the designer has to cut corners to hold gross weight down so that the ship may be launched easily, and not fly at excessive and dangerous speeds.







Chapter Nine

HOW TO FLY

Before considering adjustments and flying procedure, it is well to understand the effects of various design features upon the airplane's flight. To begin with, a ship that has much lift through such features as a thick or high lift airfoil, pronounced decalage (angular difference), or light weight, or any combination of these attributes, must be flown with relatively low power and at rather low speeds that are matched to the slow gliding speed. As a rule, this is a calm weather airplane, but one that loops easily when stunting is desired. A ship having any or all of the opposite attributes will fly faster and with better wind penetration.

The RC job is hand-glided like any free flight airplane and the familiar trim corrections are made to obtain a fast, straight glide, without a trace of flare at the landing. If tail heavy, the weight may be shifted forward, incidence removed from the wing, or added to the stabilizer. But if angular difference must be decreased beyond the safe limits previously described, it is necessary to change the CG position, even if some rebuilding is necessary. If the plane appears nose heavy, any or all of the required corrections are in order. If unreasonable or drastic adjustments become necessary, revise the airplane before attempting to fly it. This sometimes happens to the most expert builders. For example, a plane having a bad wing warp may fall off on the wing and slide into the ground when hand-glided. It may build up a spin under power and, despite opposite control, could hit the ground.

Engine-on test flights are made with a moderate amount of power. Do not throttle all the way back, as with a rich mixture, because sufficient thrust is needed to pull the machine through mild stalls or mushy trim attitudes. Do not lean out the engine, on the other hand, because poor trim may result in violent zooms and turns which could give the beginner a hard time. One good system is to put the propeller on backward, then permit the engine to rev up. About one-third the thrust is lost but the engine will run reliably and develop enough thrust to climb the machine. Torque does not vary drastically when the prop is reversed.

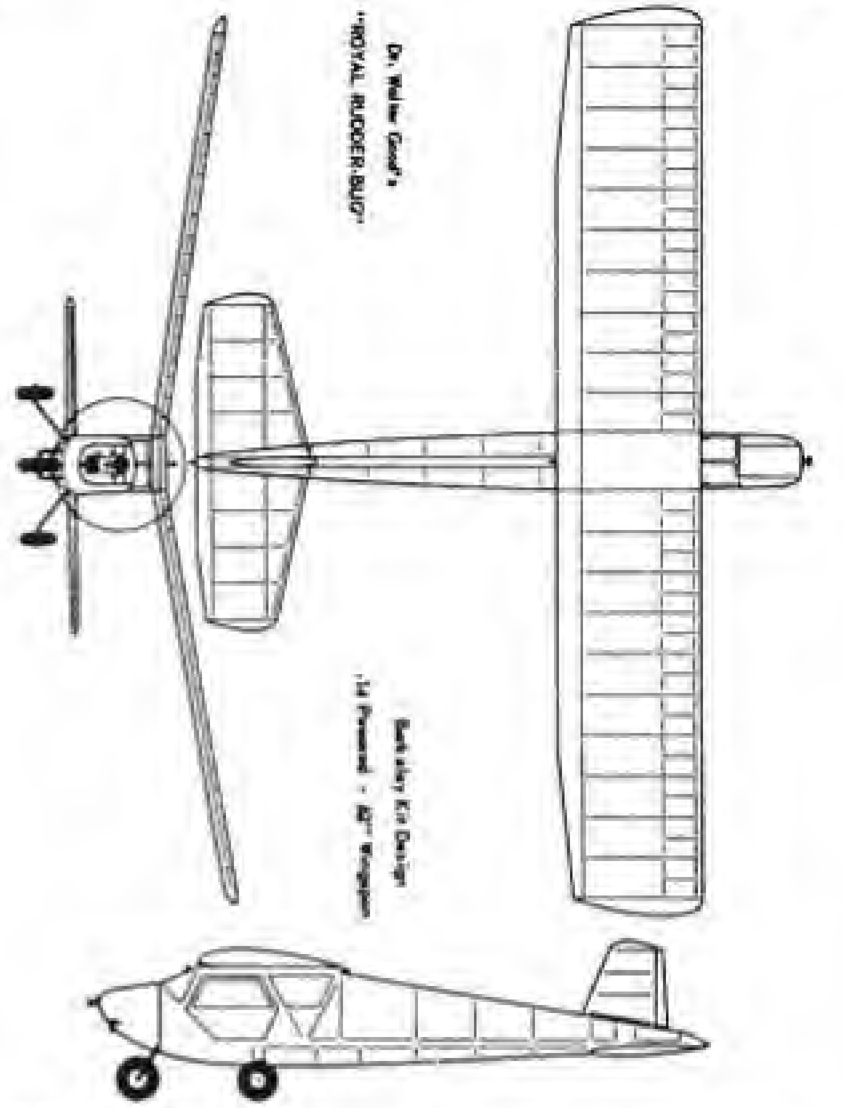
On the first few flights use enough fuel to last thirty seconds to a minute, at the most. Try to keep the plane well out in front of you, and do not, at first, make any turn more than 45° without recovery in the opposite direction. This prevents the ship from breaking away to head downwind as the result of overcontrolling on your part. A few short, upwind flights, with a minimum of maneuvering, will give you the feel of the controls and indicate whether or not control action should be increased or decreased for reliable response.

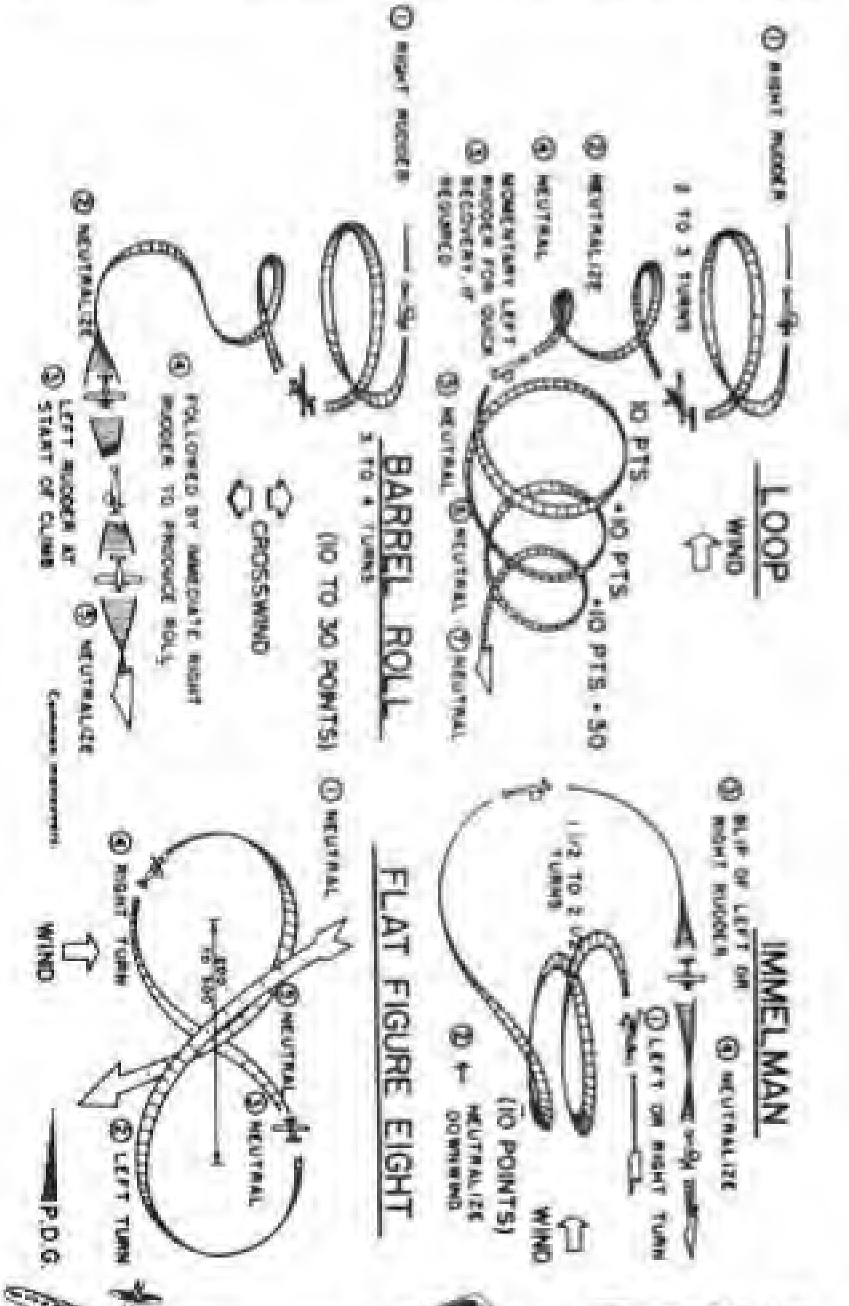
Rudder reaction will vary with the flying speed of the airplane, differing between power-on and power-off flight. Whenever the nose rises, as when the ship hangs on a prop or mushes during normal flight, rudder response is sluggish. To eliminate periodic lapses in effective rudder action be sure the ship is trimmed properly. Try to minimize the difference between power-on and glide speeds by keeping the glide a trifle fast and the engine thrust slightly reduced. In a properly designed machine, this difference is never severe.

Rudder response should be sufficient to take the airplane out of a steep turn and to swing it into a turn in the opposite direction. Thus, if the airplane is placed inadvertently in a spiral you can be sure of making a recovery. Many a first flight has been made by holding rudder steadily against an in-built turn tendency, just because enough rudder response had not been provided. This is another reason why long motor runs should not be used with a new ship or by a beginner pilot. Poorly adjusted models, which includes most new airplanes, may build up violent maneuvers, especially when the flier is inexperienced, so it is reassuring to know the engine will not run forever. Of course, too much rudder response is possible. If you think you have extra rudder response try the control gingerly the first time, and don't hold down the button.

How much rudder movement? How much area? While this is hard to answer because of variations in design, it can be approximated, assuming CG position forward of forty per cent of the wing chord. In this case the movable rudder should be about twenty per cent of the total vertical tail area. A tall thin rudder is preferred to a short, wide one, as its action is more effective. The latter type is extremely weak on the glide, consequently forcing an excessive amount of area or movement that makes power flight too responsive. In the case of an .09 to .15 powered ship, 1/4-inch movement of the rudder to either side should be plenty to begin with, and it may be cut down to 3/16 or even 1/8-inch movement later if desired. Other size ships may be judged accordingly. This set-up should give abrupt response, enough to take care of any contingency during test flights.

As soon as the plane becomes airborne it will be obvious immediately whether or not it is out of trim. Any tendencies to stall or turn may be corrected. It is desirable to judge these things first from the glide. If adjustments become necessary in order to make the plane fly at all, before you get chance to study the glide, remember that, ultimately, the glide should be perfected and, only then, the power portion of the flight. This is the same procedure used in free flight. Power adjustments are controlled by down and side thrust. Use side thrust to make the ship fly straight and down thrust to hold down the nose while the engine is running. It is impossible to make final power adjustments until the glide is proper.





It is smart practice to leave just a trace of a circle in the plane, both under power and in the glide so that, if anything should go wrong, the ship would cover a minimum amount of ground before coming to earth.

If it becomes impossible to hold down the nose with downthrust under power, the glide being correct, a smaller engine or less thrust is required. Thrust can be reduced by using lower pitch props, smaller diameters, and rich running. Wide blades, thick blades, with a lot of wood, will reduce rpm's by 500 or more. Sport fuels, adding castor oil to hot fuels, will help. An extra big prop often has the opposite effect to what the flier expects. Engine efficiency may drop off, true, but the propeller efficiency is so high that the combination of engine and propeller is more effective than before. The intake opening can be cut down with a wooden plug so that revolutions are less even when the engine is leaned out. Or reverse the prop.

The most important trick of the trade is the killing of stalls, resulting from maneuvers during which speed builds up, by use of rudder. When the nose comes up, turn the ship with rudder, just enough to convert an incipient zoom into a climbing turn. Even a well adjusted plane sometimes stalls, as in a recovery from a spiral. Amazing things can be done with rudder. A ship that is slightly nose heavy under power, can be kept aloft by starting a turn in one direction, then abruptly reversing it, and continuing the action for as long as necessary. Properly done, the plane appears to rock from side to side. This rocking motion will get a plane into the air after a poor launch that might strike the ground, or help clear obstacles that loom ahead. It will affect a good landing when the plane comes in too steep and fast. Slowly waggling the rudder, rocking the wings, will bring up the nose and slow down the speed. Smooth three-point landings can be made by turning the nose slightly while still a few feet in the air, picking up additional speed as the nose drops farther, then using opposite rudder for recovery. The extra speed provides enough lift now to nose up the craft, flaring out for a scale type landing.

Holding steady rudder produces a spiral; break the recovery zoom and stall by turning. If a spiral is continued long enough and no corrective action taken as the plane begins its recovery zoom, the ship may continue over for a beautiful loop. A snap roll sometimes can be performed during the recovery from a spiral by quickly applying and instantly relaxing rudder, as left rudder after a right hand spiral, then reversing and holding the rudder (right in this case). A slow roll may be done by holding rudder briefly until the nose starts down in a turn (beginning of spiral), then using opposite rudder until the nose again begins to drop in the other direction, and repeating the rocking action until the plane almost goes on its back. When it appears that the ship is ready to roll over, hold steady rudder to complete the job. If there is sufficient altitude, play around with spirals done after spirals, all of brief duration, and you'll discover methods of

performing many advanced maneuvers.

Wind affects flight. A job that is trimmed for a slow glide in calm weather may stall in the wind or, if trimmed for windy weather flying, it may glide too fast in a calm. Since modelers are plagued with wind, it is better to trim for moderate breeze. Control response may become sluggish especially when flying cross wind. The green pilot may be fooled by the delayed action into thinking he has no control at all. It is necessary to hold signals longer. Rudder response that permits only a gentle turn in the calm probably won't turn the ship at all in the wind. Reserve control action is required. It is advisable to employ more control action than actually needed at all times. Linkages, control horns, and bellcranks always permit adjustment for more or less control action.

The way to maintain control on blustery days is to keep the ship well upwind: always avoid letting the plane get behind you, or downwind. Stay far enough up-wind so that all turns may be completed with the ship still in front of you. For some strange reason, a radio job is much more difficult to fly back against the wind, looking at it nose on, than it is to control it when it is going away from you into the wind. Avoid all violent turns and acrobatics in strong wind. Anticipate maneuvers. If, for example, you wish to recover from a turn on a 90° heading, apply opposite rudder well in advance of 90°, otherwise the ship may end up with a 180° turn! If things get too hot, let the ship fly itself for a few seconds until it smooths out its flight path. This is a good rule, too, when performing stunts when the ship gets into some awkward position. It will fly itself out of trouble.

Consistent, accurate spot landings can be made by standing on or as near the spot as possible and by following a standard procedure or landing pattern, as is done with full scale aircraft. If a standard pattern is followed, it should be possible to get the airplane into an identical key position for every approach, provided, of course, that enough altitude remains after the engine quits. The writer prefers the plane to pass on the left, gliding downwind, then to swing around 90° into a base leg (crosswind), and finally into another 90° into the final approach. The length of time on the downwind and base legs can be varied with practice, according to the wind, going farther downwind when the wind velocity is small, and vice versa. By setting up a base leg, you provide yourself with a multiple number of points from which the ship can finally be turned into the final approach. With practice, it becomes possible to round the corners of this pattern, making a 180° turn from the downwind leg into the spot. Big and small, heavy and light models will vary greatly, but a standard pattern minimizes errors.

When high up, it is better to maneuver overhead than it is to glide far away in order to make an approach. The long approach is very hard to judge, especially with a fast, shallow gliding plane. Excess altitude can be dissipated by gliding back and forth from side to side overhead, finally swinging out to begin the landing pattern. Greater propeller diameters and lower pitches assist climb, especially in combination. Low pitches make for worse stalls since thrust is maintained well despite a nose-high altitude; the plane hangs on the prop and may whip stall. High pitch props slip enough to take the edge off stalls. But in a spiral or other high speed maneuver, the high pitch props really shift gears and very high air speeds result.

The most suitable props for all around performance: 9 x 4 to 9 x 6 on .15's; 8 x 3½ to 8 x 6 on .09's; 9 x 6, 10 x 6, 11 x 4, on .19's; 11 x 5, 11 x 6, 11 x 8, 12 x 5 on .29's Props should be matched to the plane. For example, a small, fast flying .19 job would use a 9 x 6, but a slower, bigger ship would get maximum thrust from the 11 x 4.

When downthrust is present, or when wing and stabilizer both are set at a positive angle to the thrust line (that also is downthrust), a low pitch, fast turning prop, will increase thrust at low airplane speeds, as after the launch, tending to pull the nose down until forward speed becomes high enough to develop the necessary lift, when the ship noses up. This accounts for the tendency of some RC's to dive toward the ground on launch. But this low pitch will make the plane "drop dead" in the air, just as low pitches do in U-control. The higher pitch will climb smoothly but, developing lower thrust at low airplane speeds, as in launching, requires harder running to get the plane airborne.

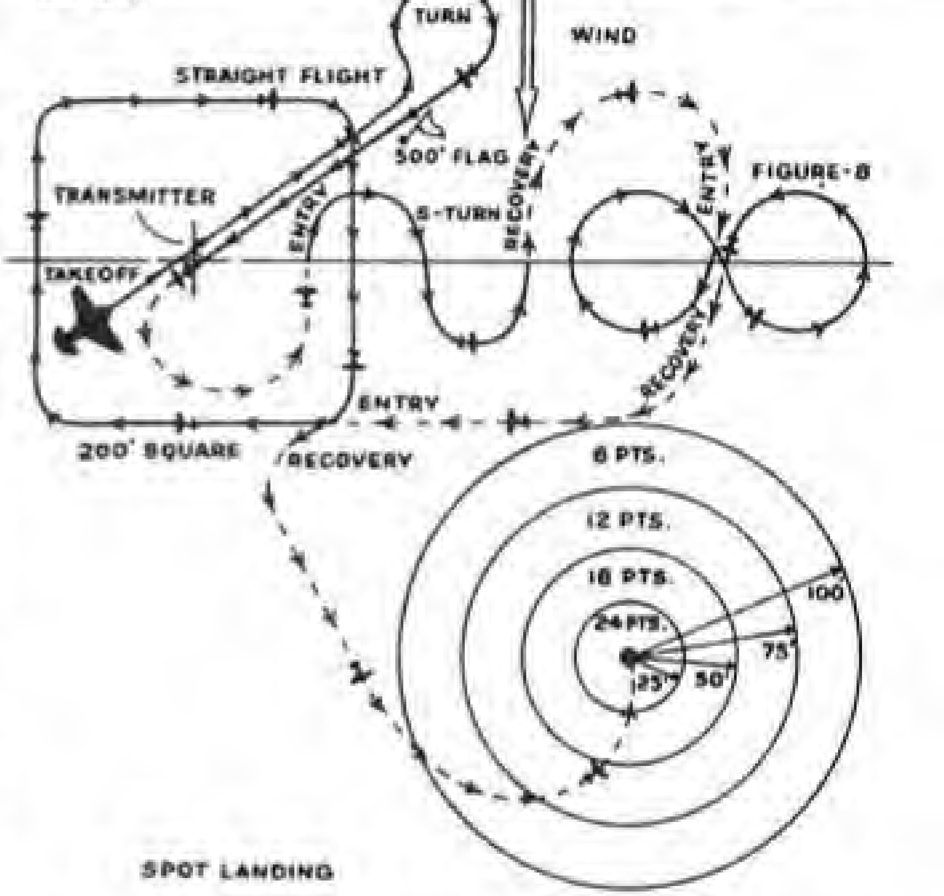
Marginal performance resulting from overweight may be improved by experiments with propellers. A sluggish .09 ship sometimes will compare with an equivalent .15 airplane by the use of a thin blade 8 x 3½ prop. A .15 job will perk up with a thin blade 9 x 5. Go to narrow, thin, light blades for higher rpm's and additional thrust.

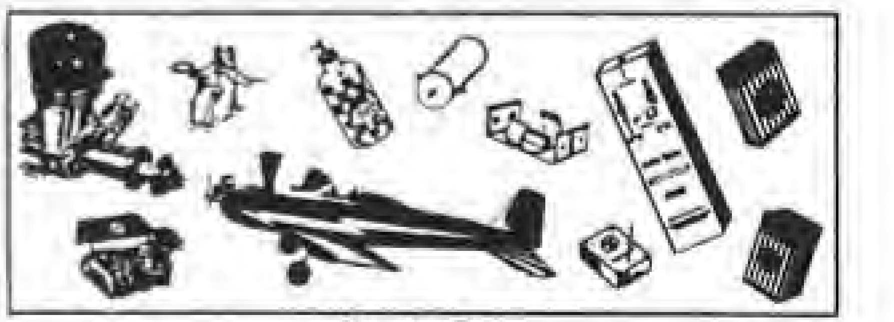
If, despite proper mounting of the radio and adjustment of the relay, you encounter vibration troubles, make sure that the propellers are carefully balanced and that the engine is turning within some smooth range of rpm's. A Torp .19, for instance, turns as smooth as silk at high rpm, as on a 9 x 5, or even an 11 x 4, but throttled back and richened up it can shake a seven-pound airplane hard enough to make the rudder skip. Many engines have rough spots in the rpm range; the designer simply did not intend them to be used with oversized props, or at medium rpm's. Persistent overheating, even of broken-in engines, can result from overly big props, high pitches, hot fuels, and hot plugs, and this almost certainly results when all these factors are present on a hot day. The engine will seem to lean out persistently–but it may be a bad case of overheating.

For normal flying, once experience has been gained, three minutes is an adequate motor run. The time seems much longer in the air. Short motor runs conserve batteries. Unless you require a full tank of fuel for contest work, there is small justification to risking a valuable plane with ten-minute motor runs, particularly on windy days. Even the heaviest RC job can ride a thermal.

Full stuntability depends on good fuel feed. Do as you would do in free flight; check the engine running with the nose of the plane up, but get the engine to run nose-down as well as nose-up! It may be necessary to plug the venturi to achieve this happy condition. A good tank installation will feed fuel steadily to any engine in good condition, if the feed line isn't too long, in any maneuver on a rudder-only airplane. Any oversized free flight tank is suitable but one of the best arrangements is a short U-control wedge tank, with the wedge down. Mount the top of the tank about one-third the tank depth above the needle valve level. A combination gravity-suction feed results. Over-elevatored planes which go through abrupt changes in direction may compel the use of a pressure type of tank, such as the Walker balloon tank with regulator.

Sooner or later every flier likes to make a long cross-country flight. In the distance, the plane is little more than a black dot. It is difficult to tell which way it is turning. Suppose, for example, it was flying broadside to you, and you used rudder to turn it back. How can you be positive which way it turned–did it come toward you, or did it go the other way? If you forgot the sequence, this can happen easily. Such tricks as painting one-half the plane one color, and the other half another, in order to check turns, is impractical, because the ship is opaque at a distance. Good technique for distance flying is to work the rudder at regular, frequent intervals, turning the ship just enough to detect a change of heading. By always doing something with the ship, you always know what control is coming up.





Chapter Ten

OPERATION

Satisfaction from making numerous flights with a minimum of fuss results from a clear-cut operations procedure. There is inevitable chore work, such as checking batteries, relay operation, inspecting escapements, making ground checks, etc., but these duties are rendered painless if incorporated into a standard procedure. Begin by putting both the ship and equipment into order before the flying session. Don't expect to do it on the field. Unexpected problems, however trivial, may ruin a flying session. A pre-flight check should include an inspection of wiring, replacement of weak batteries (receiver or transmitter), a check of the relay and escapement, linkage, etc., and finally operating everything with the transmitter.

Arriving at the field, decide upon the best location, according to wind direction, open area, nearby housing, etc. (Why is it that modelers tend to group under the only tree within a quarter mile?) If you have a stationary type of transmitter set it up before doing anything else. Check the airplane batteries and see that the transmitter operates the receiver before walking out on your ground check. This check should be simple and quick, not a Four Power Conference. Assuming you have a helper, work out an easy system of signals: you can't talk back and forth with, say, 800 feet between you and the helper while other engines are running.

When ready to begin tuning, hold up the arm; the helper switches on the transmitter in response (why wear out batteries while walking back and forth?) Make a circular motion with the upheld hand, indicating that you want a steady signal held on, while you tune the receiver. Then, as you note the signal on the meter plugged into the plane, begin to tune for maximum drop or rise, as the case may be. When tuned, raise the hand again, helper still holding signal, then drop the hand. He cuts off the signal. By up and down movement of the hand you can call for any speed or duration of signal you want. Idea is, that whenever the hand is up, the helper holds signal; when the hand drops, he releases signal. The circular wave in the beginning is to signify that you don't want the signal cut off when the hand is dropped in order to tune. Later, you can dispense with the rotary signal, for the helper will know that you intend to tune. For long ground checks wave a white cloth to clarify signals.

It is surprising how mixed up two people can become during a ground check. Suppose you call for a signal and the meter indicates nothing. So you glare at the helper for stupidity in not turning on the transmitter. But he can't see this. You wave frantically to wake him up. Meanwhile he has been sending a steady signal, and wonders if the transmitter is on the blink. Confusion can be avoided by having the helper follow your hand signals. When the receiver does not work and you have your hand raised steadily, he holds his hand up to signify obedience. You know then that the transmitter probably is working.

A commonly made error during ground checks is to walk out a goodly distance before calling for a signal. Although the receiver seemed in tune next to the transmitter it may be far enough out of tune at a medium distance not to pick up the signal. This can lead to futile and protracted tuning if the adjustment is lost, while batteries run down merrily and other fliers on the field grow grumpy. It is better to try the ground check quickly at, say, 50 or even 200 feet, and only then at progressively greater distances. After you know your equipment you will find that a certain rise or drop takes place at a certain distance and super ground checks are no longer necessary.

When ready to fly, assemble the ship—don't forget any of the wing or tail hold-on rubbers. (And who hasn't seen a wing come off in the air?) When you see that you can safely fly, allowing for other fellows whose planes may be gliding silently overhead, start the engine; have the helper hold the ship tail toward you, fifteen or twenty feet away, and check the rudder operation by sending a number of quick signals. The rudder should follow exactly. If it misses even once do not fly until the reason is found. If everything checks out, wave the launcher the release signal. Always, when checking the rudder, have a known position coming up. Make it the same position on every flight. Most fliers choose "right next" because it is opposite to a left turn tendency caused by torque. If correction must be made for a poor launch, one signal would give right turn, and two left, on self-neutralizing escapements.

If you own a hand-held transmitter, you may have a big advantage in being able to launch the ship yourself while holding the transmitter. Cradle the transmitter in the crook of one arm and launch the plane with the other. The rudder check, motor running, can be made by standing the plane against some object to prevent its rolling. If the plane becomes slippery from exhausted fuel, wipe it off before someone makes a bad launch.

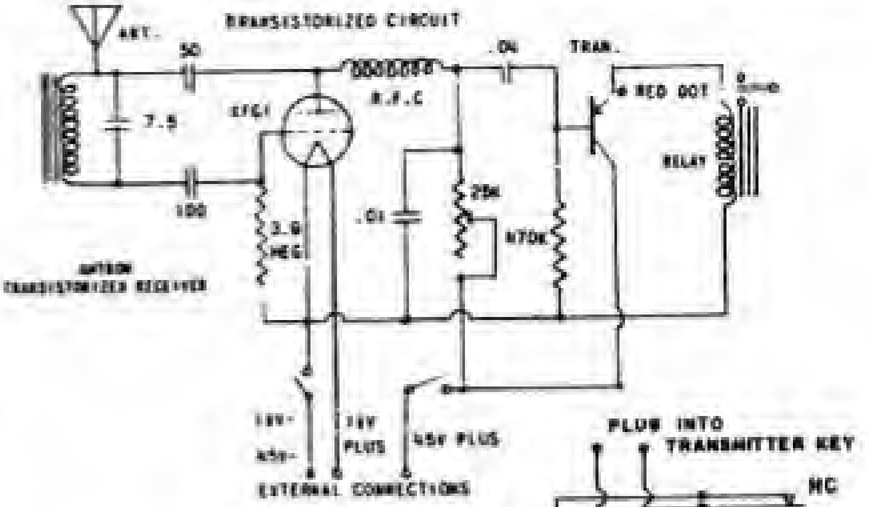
If a long flight is made, allow the batteries to recuperate for a similar period. Check the escapement rubber windings for a long, active flight can run off a double row of knots on the rubber. Otherwise, after every three flights, wind the escapement as routine and, after a half dozen flights, check the airplane batteries. Should the wind be blowing, stand the model on the ground, tail to the wind, to prevent the ship's being blown over. In the hot sun, place a rag over the wing hold-down rubbers which otherwise might snap, perhaps in flight.

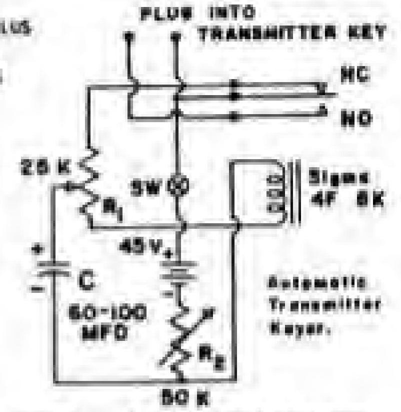
One of the most annoying aspects of radio control is the aerial traffic jam on 27.255 megacycles. Field etiquette is essential. People must cooperate with each other if everyone is to get in his fair share of flights—and how about the oaf who fills up his ten-minute tank when a dozen guys are watching that sinking sun! It is recommended that a common take-off point be established. If many fliers are present, they should line up planes ready for take-off. Anyone with engine trouble should step aside to the next man up. Who doesn't know a character who jams up such a line for fifteen minutes until he discovers the glow plug is burned out?

Some groups use flags: green for the air is clear, red for someone on the air. Trouble is that flags can't yell and everyone forgets to look at them. People paint planes various colors to designate frequencies, or use nifty signs and decals, and no one appears to pay any attention. A blast on a police whistle just before launching wakes up the dreamers but once a ship is high in the air, they forget about it. Noisy engines help—you can't hear an .049 at 500 feet while bigger engines run near-by. When many fliers are out, keep your flying near-by and at low altitude; don't let them forget you!

But people who fly a great deal together find it possible to operate without talking, if they have to. Listen for engines starting. The chap who walks out to the firing line, with engine running, should be given the air. If you do this, tarry long enough before launching to make sure that random transmitters are not working your rudder.

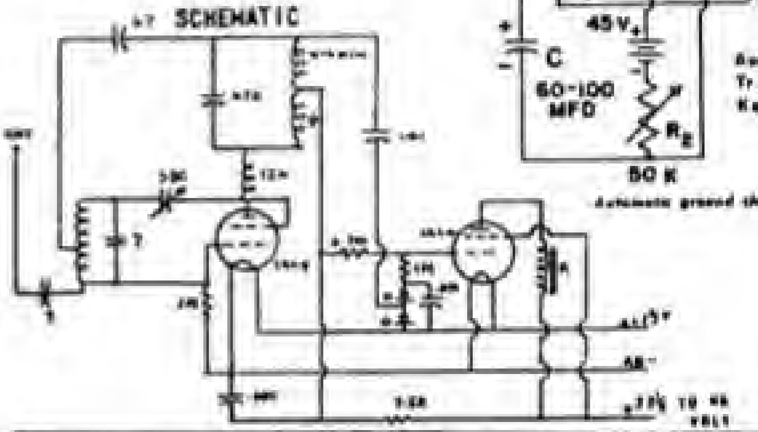
It is imperative that RC fliers group together on the field. Rugged individualists and lone wolves are certain to wreck someone's plane. A cooperative group of fliers always seems to know when a ship is in the air and don't hesitate to yell when a second plane makes ready for a launch before the air is free.

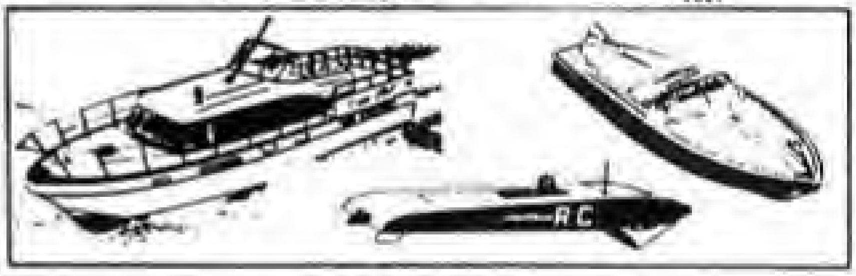




Automatic Transmitter Keyer.

Automatic ground check keyer.





Chapter Eleven

BOATS

Radio control boats have become popular and their number increases daily. Boats have many desirable features. When compared with aircraft, there is no danger of loss, as out-of-sight flight being impossible. Damage rarely results from equipment failure or operational error and then usually only when a largish, fast boat strikes a concrete wall or other solid obstacle. Wind is less of a handicap. In warm weather a boat fits in better with family activity, since it can be taken more readily on swimming trips, picnics, etc., and requires less space in the car. A boat is ideal for experimenting with radio equipment.

Most boats are built from kits. Excellent construction kits, some being scale models and others of original design, are available from your dealer. Engine manufacturers are following through with various lines of marine engines, from Half-A's to .29's or so. Many of these are genuine marine engines, not just airplane engines with special attachments. At least two manufacturers make small outboard type internal combustion engines. It takes a critical eye to tell them from the real thing. These engines clamp onto the boat transom, just like a big outboard, and are adjustable for angle, and have pull cord starting. Other engines are produced with an awareness of the heat problem from enclosed running. Water cooled marine engines are found in at least the .049 and .09 categories.

Several complete lines of marine hardware are available, such as beautifully machined propellers, stuffing boxes, drive shafts, universals, and so on. There is little than can be added here in the way of information because the boats, the necessary hardware, and suitable powerplants are abundantly available; all are of top quality and it is practically impossible to bungle the job.

Boats do have noticeable difference from planes. Battery weight is relatively unimportant so that big, dependable batteries can be used for long life and steady operation. Equipment can be made accessible by means of decks that lift off, removable pilot houses, and so on. Powerplant and escapement or servo installations require special attention. Internally mounted engines, adapted from airplane designs, sometimes have given cooling problems in the past, this being aggravated by poor ventilation.

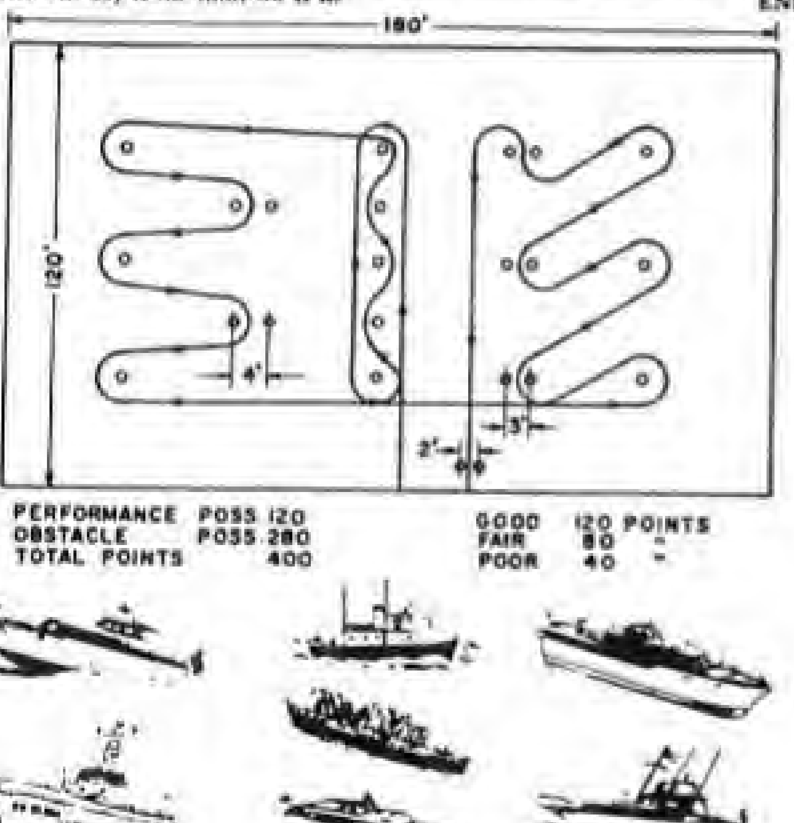
Some hobbyists, especially ex-airplane modelers, go in for air boats in which an airplane-type engine and propeller are mounted on a pylon at the stern. The prop may be either a tractor or a pusher. Claimed advantages are simpler installations, elimination of boat hardware, such as stuffing boxes and shafts, positive cooling and easy starting. But to the purist such a boat may be an eyesore, especially when some beautifully built craft, otherwise to scale, is marred by the unsightly pylon with its engine and massive air prop. Moreover, air boats are said to be tricky on rough water or when traveling crosswind.

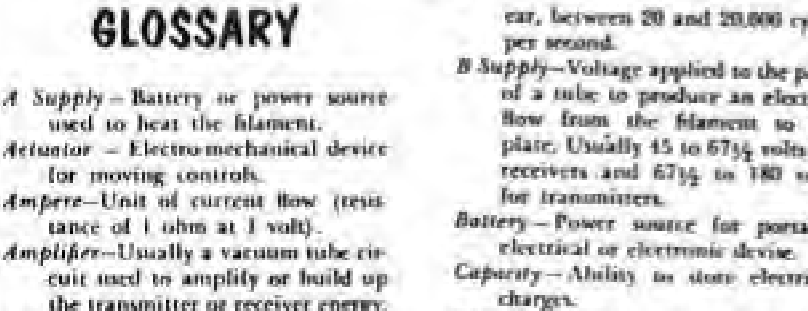
Boats offer many possibilities unthought of in aircraft. For example, it is quite practical to install a milliammeter in the boat and to read it by means of binoculars while the craft is in action. One well know radio equipment designer has just such a rig. His boat is powered by an electric motor and batteries. Its quiet running allows the owner to mystify flocks of ducks at rest on the water.

Escapements may be a problem on bigger, heavier, faster boats because the loads upon the rudder are greater than those on an airplane rudder. When the rudder swings over in a plane, it encounters small resistance, but water is incompressible. Water must be pushed out of the way, and this delays escapement action. More rubber on the escapement is called for. In a boat of any consequence electric motor driven servos with gear drive would greatly enhance the flexibility of performance. Some special servos for boats are on the market and more will be available soon.

Although radio control is a booming activity, the surface hardly has been scratched. Fascinating possibilities are ahead. A radio controlled model boat has successfully sailed the English Channel. Under International Rules governing plane size, weight, and so on, radio model aircraft have established duration records. Point-to-point flights with landings and take-offs at different air fields, closed course racing (for planes or boats), aerial picture taking, are among the feats already accomplished. Rapid technical progress toward multi-controls means that in a few years true proportionate, multi-control systems will become available. The sky is the limit—or is it?

END





GLOSSARY

A Supply—Battery or power source used to heat the filament.

Actuator—Electro-mechanical device for moving controls.

Ampere—Unit of current flow (resistance of 1 ohm at 1 volt).

Amplifier—Usually a vacuum tube circuit used to amplify or build up the transmitter or receiver energy.

Anode—Plate of the vacuum tube.

Antenna—Conductor, as long wire, rod, etc., to intercept (as on receiver) or radiate (as on transmitter) energy, in radio wave form.

Armature—That part of the relay which is movable under influence of changing magnetic strength.

Audio frequency—Frequency heard by ear, between 20 and 20,000 cycles per second.

B Supply—Voltage applied to the plate of a tube to produce an electron flow from the filament to the plate. Usually 45 to 67½ volts for receivers and 67½ to 180 volts for transmitters.

Battery—Power source for portable electrical or electronic devise.

Capacity—Ability to store electrical charges.

Carrier—Short for carrier-wave, current or frequency of radio wave.

Cathode—Electrode in tube from which electrons flow.

Channel—Single, particular frequency of carrier wave.

Choke—High inductance coil opposing passage of pulsing current, but allowing direct current to flow.

Circuit—Path of electrical current, returning to source.

Coil—Wire winding.

Condenser—Two conductors divided by non-conducting medium.

Contact—Metal parts brought together to complete a circuit, as in switch, relay, etc.

Coupling—A means of transferring energy from circuit to circuit.

Crystal—Quartz or Rochelle salt crystal cut in small thin disc or square for maintaining a given frequency.

C W—Abbreviation for carrier wave.

Diode—Tube containing cathode and plate for passage of current in one direction.

Electron—Smallest charge of negative electricity.

Escapement—Actuator driven by power of spring or twisted rubber.

Filament—Heater in a tube, similar to the filament wire in light bulb.

Filter—Combination of resistances, inductances, etc., to allow passage of certain frequencies intended to operate more than one actuator. Replaces function of reed bank.

Fuse clips—Small metal clamps to hold wire leads of tubes; replaces tube socket.

Grid—Electrode in tube that allows, or shuts off, passage of electron stream.

Ground—The A-Plus or B Minus side of a battery and the point to which all connections common to these points are made.

Idling current—Amount of current drawn by receiver as indicated by milliammeter inserted into B-Plus lead (no signal).

Inductance—Characteristic of circuit to oppose change of current flow.

Jack—Holder for contacts that close, change, or open circuit connections on insertion of plug.

Kilocycles—One thousand cycles.

Megohm—One million ohms.

Megacycle—One million cycles per second.

Meter—Device to indicate measured electrical quantity of current, resistance, etc.

Milliampere—One thousandth part of an ampere.

Mils—Abbreviation of milliamperes.

Milliammeter—Meter reading milliamperes.

Modulation—Controlled variation of amplitude or frequency of carrier wave according to transmitted signals.

Ohm—Amount of resistance at 1 volt and 1 ampere.

Pentode—Five-element vacuum tube.

Plate—Output element, or anode, in vacuum tube.

Plug—Machined metal end for wire, inserted in jack to connect external units into existing wiring. Plug may have provision for one or more wires to match circuit of jack.

Polarity—Indication of which terminal is positive and which negative.

Potentiometer—Device for varying amount of current flowing through a lead. Called "pot" for short.

Power input—Wattage fed into a radio tube, determined by voltage times current consumed.

Power output—Power delivered into the tank circuit of a tube. Always less than the power input through losses in the tube and circuit components.

Pulse—In modeling terminology, a system by which repeated signals are transmitted, varying as to length and/or rate.

Receiver—A radio receiving set.

Relay—Device which operates a second circuit from current changes in the first circuit.

Resistance—Opposition to current flow.

Resistor—Unit of known, desired resistance placed in circuit to reduce or limit current flow.

RF—Abbreviation for radio frequency.

RFC—Radio frequency choke.

Servo—Electric motor-driven actuator.

Socket—Tube socket.

Tank circuit—Coil and condenser combination placed in the plate circuit of a tube.

Tone—Sound, having particular pitch, superimposed on carrier wave, to operate controls by means of modulated or audio receiver. An audio modulated transmitter-receiver system.

Transmitter—Radio transmitter for broadcasting the signals.

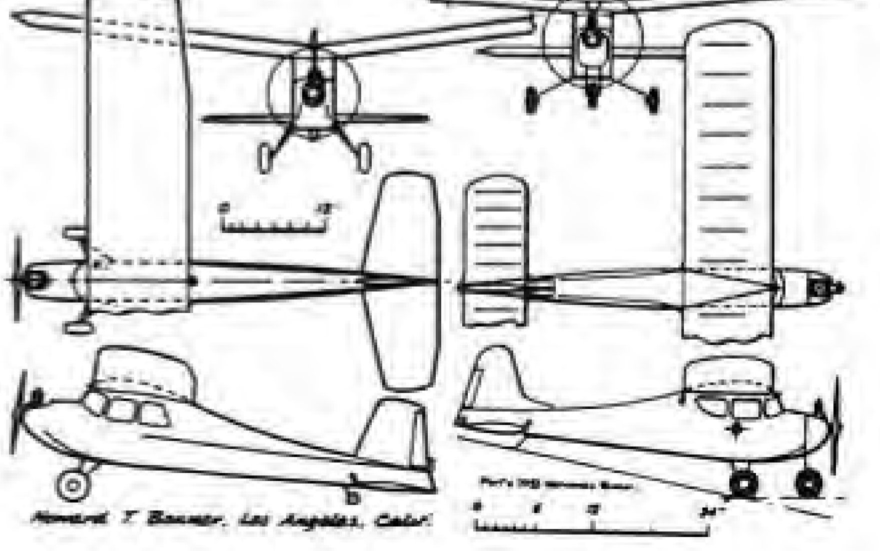
Triode—Three-element tube.

Tube—Number of electrodes packaged in an evacuated envelope.

Volts—The "force" in a battery or power source which pushes the current through the circuit.

Watt—Current flow, 1 ampere and 1 volt.

Wave length—Distance between peaks of same polarity; equal to velocity over frequency.



MICROPHONE BUTTON

As in the preceeding work on remote controls, the tubes and some other components may be impossible to get as they are obsolete. Even so, your Radio Shack salesperson should be able to tell you what modern components have replaced them.

EXPERIMENTS

With The

MICROPHONE TRANSMITTER BUTTON

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Loud Speaker Volume Radio Using Microphone Button and Crystal
Sound Through Water---Submarine Telephones
Listening Through Walls
Air Harp

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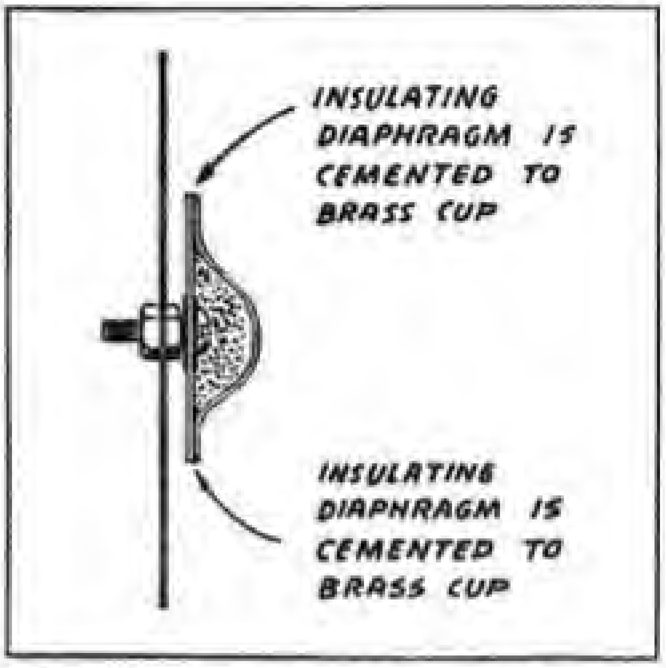
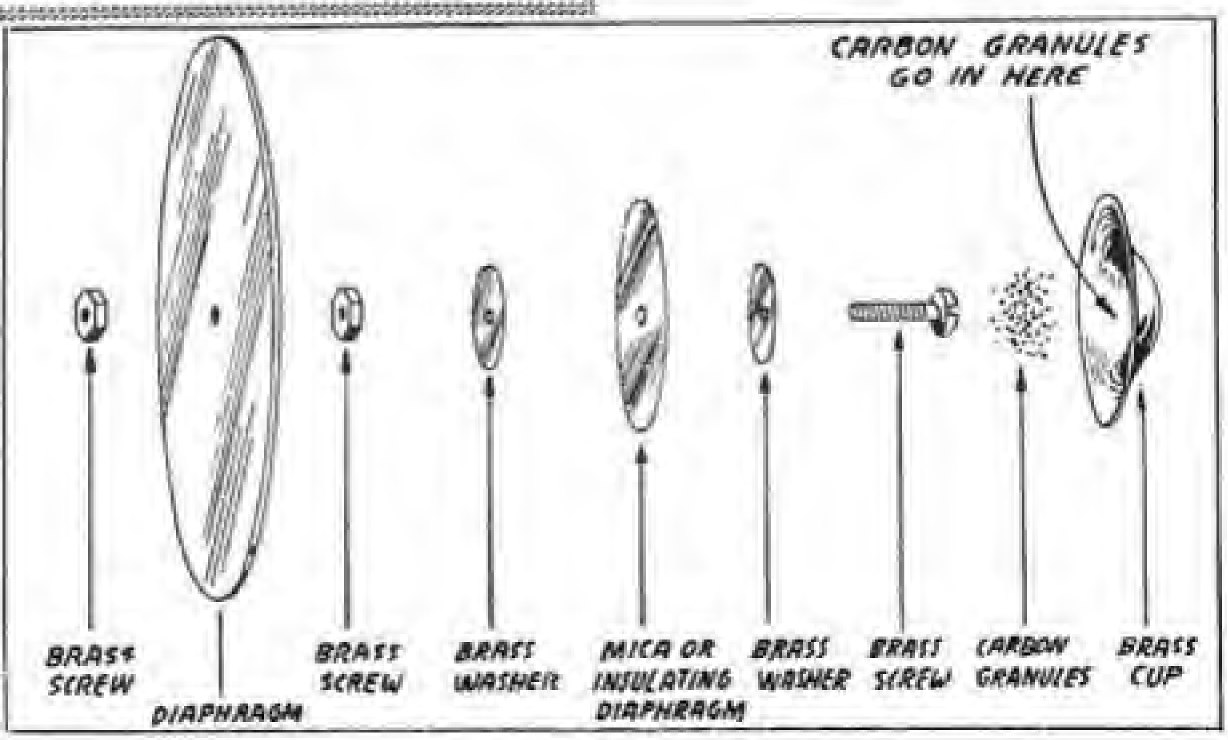


General Instructions on the Microphone Button

You will find it easy to build a Microphone Transmitter Button. This particular device lends itself admirably for use in radio and electrical circuits, and in view of the fact that many do not realize to what important uses such a button can be put, it is advisable to cover the use of this little transmitter in its various fields so that one will easily see how each and every one of the systems are applicable to radio uses. In the illustration a transmitter button has been taken



apart so as to show its internal construction.

For those who want to build their own Microphone Transmitter Button, it will be seen from the exploded view of the button, that it really is quite simple. The one illustration shows all the parts necessary for the complete construction of the button. The assembly of the button is illustrated in the smaller drawing.

The large DIAPHRAGM is made of either light copper or tin sheet metal, about the thickness of the metal used in a tin can. This makes it sensitive to picking up noises. The small or INSULATING DIAPHRAGM is made of either a stiff cardboard, but very thin, or a thin sheet of mica. A thin sheet of mica is the best, but if this is not available, use a thin sheet of rigid cardboard, something similar to post card weight.

The assembly of the button is quite easy, and the only difficulty you may have is inserting the carbon granules and cementing the insulating diaphragm to the brass cup. The cup should be about HALF FILLED WITH GRANULES. (Do not fill up.) These should be loosely packed, so they can move freely. Before you cement the insulating diaphragm to the brass cup, remember to assemble the button up to the first brass nut. Once you cement the parts together, you will not be able to get at the screw to tighten.

When you have finished the button, you are ready to proceed to experiment with the button. Read all of the booklet carefully before beginning your experiments.

The remarkable thing about this transmitter button is that it can be made to transmit in any position, either horizontal or vertical. It is so small that it can be readily concealed in any of a dozen or more places, and thus serves as an admirable detectaphone. For instance, it can be placed in a watch case; an old watch case is used and a tiny hole drilled in the center of the back of the case. The screw of the transmitter button is then pushed through the hole and the nut is tightened on the screw. This watch case may be concealed behind a group of books or may be placed in view on the table, and there is very little possibility that anyone will pick it up to investigate. The wires leading from the transmitter can then be hooked to a regular amplifier, or else may be connected in series with a battery and a low resistance phone.

If the transmitter button is held up against the throat it will be possible to transmit speech without actually talking at the button. Experiments in talking through the throat and also talking through chest, have been numerous, and at the present time most of the airplane transmitters for communication between observer and pilot employ throat microphones. These microphones are strapped to the throat of the user who talks just as though he were talking to a friend alongside of him. In this way the noise of the engine is overcome and successful transmission is possible. If a tiny hole is drilled into the side of a glass and a person should talk towards the glass, it will be found that speech can easily be transmitted in this manner. This makes a very nice little experiment for electrical clubs.

Music from a phonograph can be transmitted to distant places by employing the hook-up wherein a small hole is drilled in the side of the tone arm of the phonograph, and the screw of the transmitter button is inserted in that hole. There are several other means for doing this perhaps a little more efficiently than indicated here, and these will be described elsewhere in the article.

These transmitter buttons can be used as detectophones for conveying speech to detectives or operatives stationed elsewhere in a hotel or in the house. In the one case a microphone button is mounted in the back of the picture. The tiny screw on the surface of the picture is not noticeable to the casual observer and any plot could not easily be detected. It is advisable, however, in placing microphones in suspected positions, to locate several of them in the same room and use different sets of wires for each, running each pair out of the room through different exits. In event then that one of these detectophones is discovered, there are still two or three of them in the room which remain to be discovered. Most criminals will assume that when they have once destroyed one detectophone that they are free from further interference on the part of this silent watchman. If several detectophones are placed in the room a complete transcription can readily be taken by the reporting stenographer.

In event that a minister should have several sick members belonging to his parish who are unable to attend Sunday services, it is possible for him to place one of these small microphone buttons in front of him in the pulpit. In this way he would be able to transmit the complete text of his sermon to any of those who care to listen and who are interested enough in going to the expense of stringing a few wires from the point at which the talk takes place to their homes.

For those hard of hearing such a device would be of particular benefit, as the church could be fitted with several sets of earphones and the speech, greatly amplified, would be impressed upon the diaphragm of the ear, and thus transmitted to the inner ear and brain in a much stronger manner than if the voice were merely heard in the usual manner. For transmitting the sound of a violin to persons hard of hearing and also for the production of various stage effects, the microphone button can be screwed fast to the body of the violin, or preferably to the bridge, as this latter position in no way damages a valuable instrument. In this manner all the tones of the violin are faithfully reproduced in the distant receiver, or they may be amplified by means of a regular vacuum tube amplifier such as you have in your radio set, and then transmitted to the crowds in the dance hall. Several of these microphone buttons attached to the various instruments in the band and all connected to a good amplifier could be made to fill the largest hall with music. The band itself need not necessarily be very large.

Sounds from a telephone receiver can be made to travel to a distant receiver. Here the microphone button is mounted inside of a cigar box and the receiver is then placed right on top of the position of the button.

The microphone button can be used to transmit the sound of a piano to a distant room. The button is preferably fastened to the sounding board in a piano, but it may be fastened to any convenient place on the piano to accomplish this work. This is of value where there may be a sick patient in a home on the second or third floor far remote from the piano, and who would like to listen to any music played on the piano by some of his friends.

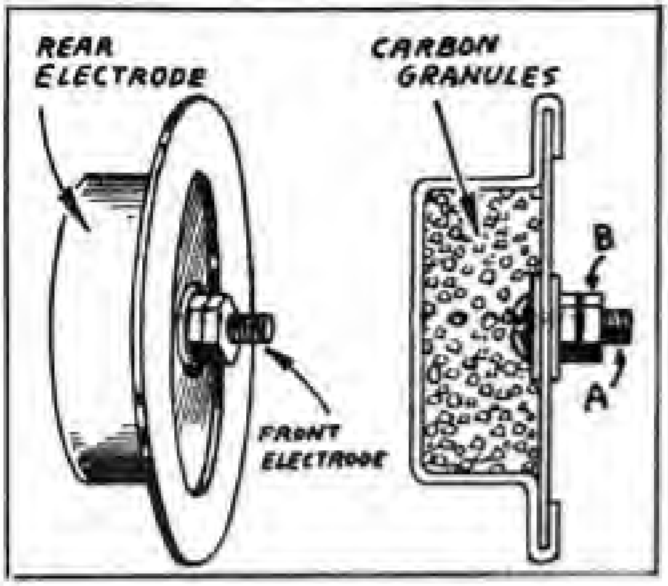
Radio music can be transmitted to distant points and incidentally amplified at the same time. Here the microphone button is soldered to the diaphragm of the receiver as indicated, and then the leads connected in series with several dry cells and a low resistance phone.

For experimenters desiring to get greater sensitivity and volume for either radiophone transmitting stations or for ordinary phone transmission. Here five or six microphones are mounted upon a thin metal or a heavy card-board disk. The screws projecting through the cardboard are then all connected by means of flexible copper wires, or in event that a metal disk is used, the metal disk itself will serve as the means for making connections between the screws and one thin lead soldered to the disk will suffice. In order to make a more classy job of the device, an old molded variometer makes a fine microphone case. The wire is removed from the variometer and then the case is packed with felt lining which should be glued to it. The disk with the five microphone buttons mounted thereon is then supported in the center of the variometer case by means of three rubber bands. The front and back of the case are then attractively covered with fine silk gauze. This makes a very presentable instrument which looks very much like those microphones used in our broadcasting stations.

Numerous questions have been asked as to why the transmitter button does not work properly. In each and every case, the answer is simple: "The button has not been hooked up in accordance with directions." There is no electrical circuit that is simpler to couple than an ordinary transmitter button and a receiver. The experimenter should remember that every transmitter button requires a diaphragm of some sort or a substitute therefore. The size of this diaphragm depends entirely upon the work which is to be accomplished or the nature of the matter to be broadcast or amplified.

For ordinary speech, a diaphragm approximately 2½ inches in diameter is better suited than one 14 or 18 inches in diameter. The smaller diaphragm enables the listener to recognize the voice of the person transmitting, whereas the larger diaphragm has a tendency to decrease the pitch of the transmitted voice. But when doing detective work, it might become necessary to attach a transmitter button directly to a large canvas picture. In this particular case, the conversation that is picked up is the all-important consideration and one does not care about the quality of the sound just as long as the speech can be recorded.

Now as to the quantity of carbon granules in this button. Slightly more than half is a splendid proportion. For more sensitive work, the quantity should be decreased and for very crude work, the button can practically be filled up. Therefore, the fewer carbon granules in the button (of course within limits) the more sensitive will be the nature of a pick-up. Coincidentally a frying noise might be produced when there is not a sufficient amount of carbon granules to properly distribute the current (frying being also due to too much current.) At no time should the current through these buttons be so high that it will produce a frying noise. While many experimenters advocate the use of a 4½ to a 6 volt battery, the use of telephone transformers was likewise suggested, but for those readers desiring to use the standard radio transformers (audio frequency types) the voltage on the button can be increased to from 22 to 45 volts, dependent upon the resistance in the primary of the transformer. If the reproduced voice develops a frying sound, the button is being overloaded; if not, then the voltage should be increased until it is just below this frying point.



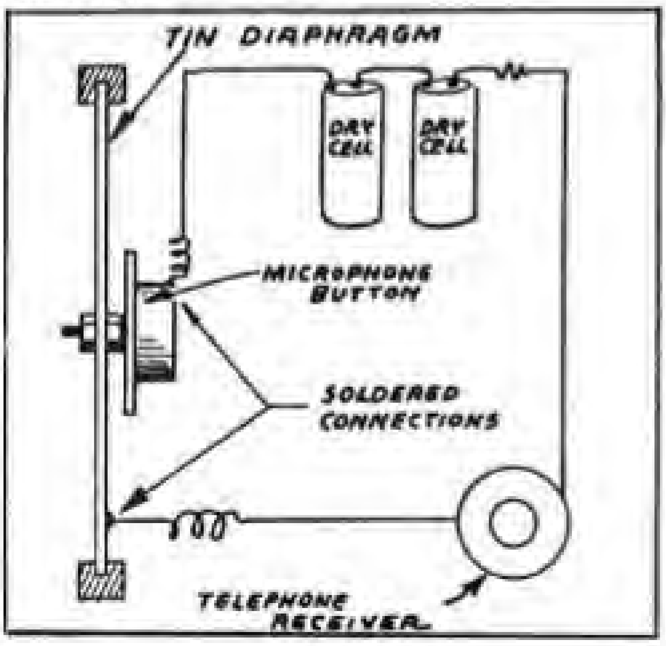
Amazing Microphone Transmitter Button

One of the most interesting little pieces of electrical apparatus is the **Microphone Transmitter Button.** The above illustration shows the construction of the button. The brass cup is the *rear electrode.* The front electrode is a brass screw mounted on an insulating disc. The inner chamber of the button is filled with carbon granules.

In all of its uses, the Microphone Button is attached to a diaphragm. Usually this diaphragm is made of metal, but any stiff, resonant material is satisfactory. When sound waves strike the diaphragm, the vibrations cause the carbon granules to be alternately compressed and released. A pressure wave is exerted upon them corresponding to the sound wave that is striking the diaphragm.

Carbon granules conduct electricity more readily when compressed, so that each sound wave striking the diaphragm is converted into a fluctuating electrical current wave in the circuit that passes between the rear electrode and the front electrode. It is this electric current wave that transmits sound wave to receiver or amplifier.

All the uses of the Microphone Button are based upon this ability to pick up sound waves and convert them into electrical impulses. It is a miniature telephone transmitter.

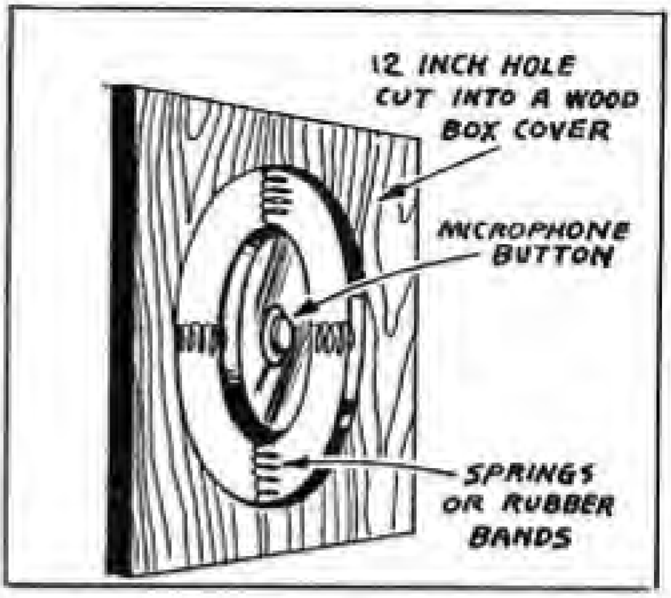


Electric Telephone

The simplest and most basic use of the Microphone Button is the Telephone Hook-up. This is illustrated above and is self-explanatory. For best results, the microphone button should be kept in a vertical position. The carbon granules should be loosely packed in the button, so that they are sensitive to the vibration of the diaphragm. If button fails to operate satisfactorily when first tested, it should be tapped firmly but gently to loosen up the granules.

In the Telephone Hook-up, ordinary 1½ volt flashlight batteries (or No. 6 dry batteries for longer life) are used. Two cells are satisfactory for good performance up to 100 feet, but for longer circuits, additional batteries should be added.

NOTE: .The Transmitter Button circuit works best with a low resistance earphone. A 6 ohm earphone is ideal, if available.

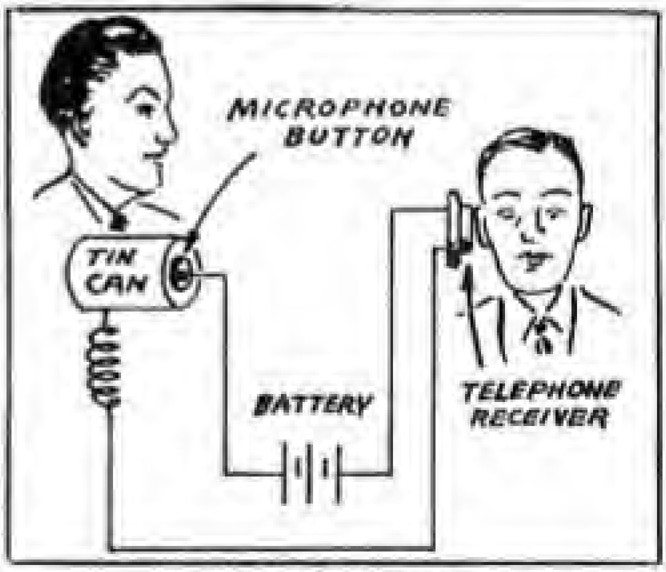


Suspension Microphone

In order to increase the sensitivity of the microphone, the suspension arrangement illustrated above is convenient to use. An ordinary 6-inch tin pie plate suspended in a wooden frame is quite satisfactory. This serves two important advantages. **One:** the suspension prevents diaphragm from picking up other extraneous vibrations. **Two:** the increased size of the diaphragm picks up more sound waves.

"Frying Noise" in the Circuit

While it is essential to have sufficient current in the circuit to obtain maximum results, a "frying noise" in the circuit indicates too much current. Ordinary dry cells work very well, but you can also use a telephone transformer. If a standard radio transformer or radio batteries are used, the voltage can be increased up to 22 or 45 volts. Remember, radio batteries deliver high voltage, but little current. Standard flashlight or No. 6 dry cells deliver 1½ volts, but a fairly strong current. Use as much current as possible, but just below the level that produces a "frying noise" in the receiver.

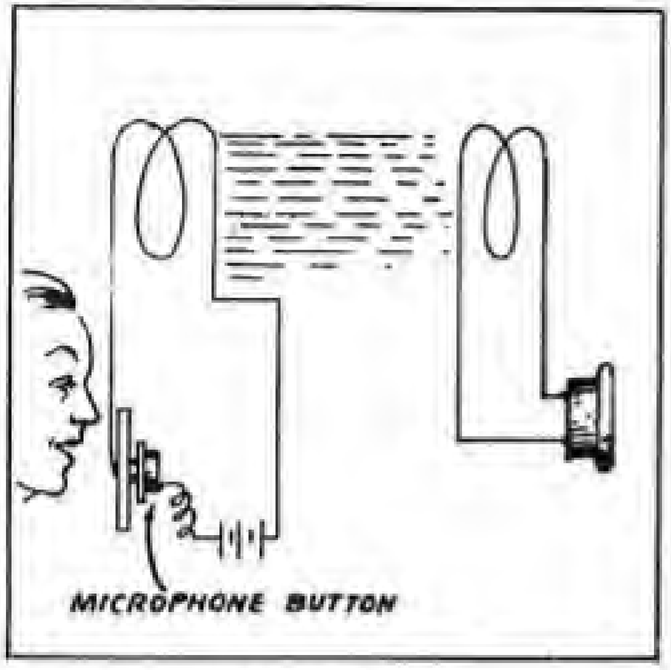


Electrical Stethoscope

A stethoscope is a "sound magnifier." It picks up and magnifies noises. A doctor uses the stethoscope to listen to body noises---the heart, the lungs, etc. A mechanic uses a stethoscope to detect unusual noises which reveal faulty machinery. A jeweler uses a stethoscope to overhear irregular watch noises. It is a general rule that in well run machinery, there is a certain rhythm. Once you become familiar with that rhythm, any discordant sound will instantly reveal trouble.

If the sounds are loud enough, the ordinary ear is capable of detecting these discordant notes. A pilot of a plane, for example, can usually tell from the sound of his motor whether it is functioning satisfactorily.

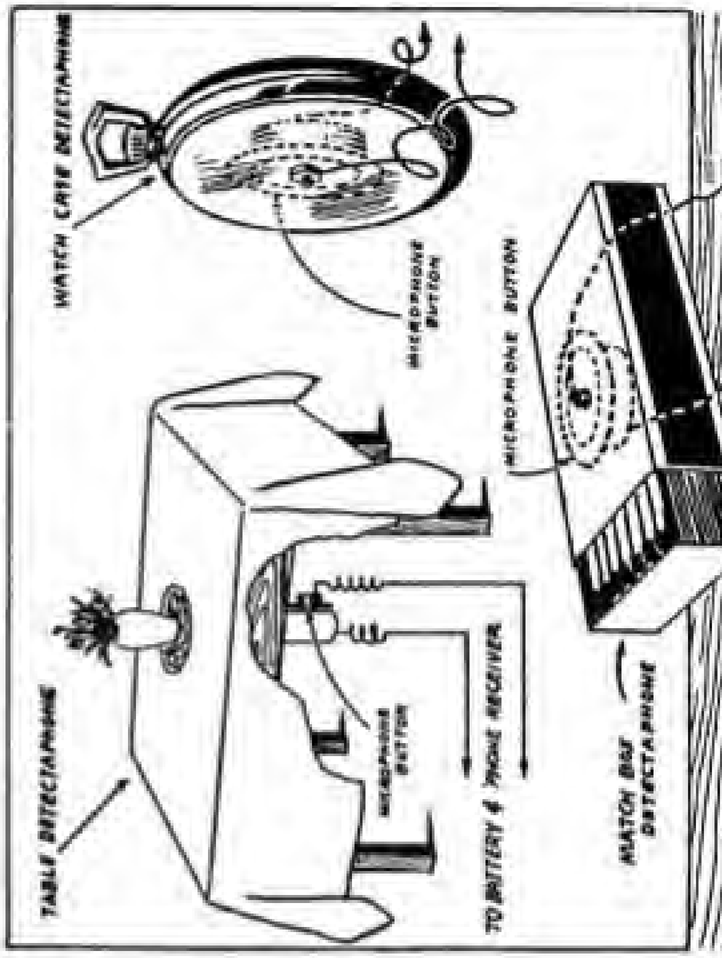
A tin can is used to pick up and collect sounds for greater sensitivity. Two or more microphones can be used. They are connected in parallel and are mounted to the same tin can or diaphragm. By "parallel" we mean that all the rear electrodes are connected together and all the front electrodes are wired together.

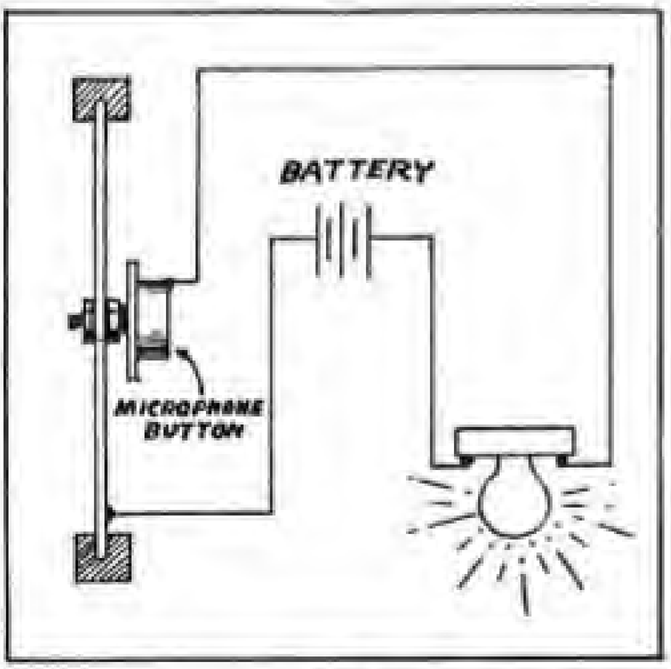


Induction Telephone

A Microphone Button is connected in series with a coil of wire and batteries. Several feet away another coil of wire is mounted parallel to the first coil. This second coil is connected to a low resistance receiver. Thus, you are really "broadcasting" the voice through the air. This is essentially the principle of radio.

This same principle can be used in magical or mystical acts. In one case, a coil of wire was wound into a carpet. The second coil was placed around the waist of a medium. A tiny receiver was fitted into the ear of the medium (similar to those used in hearing aids) and concealed by a Hindu head-dress. An assistant telephoned the secret, written questions to the medium via a Microphone Button connected with the coil in the carpet.

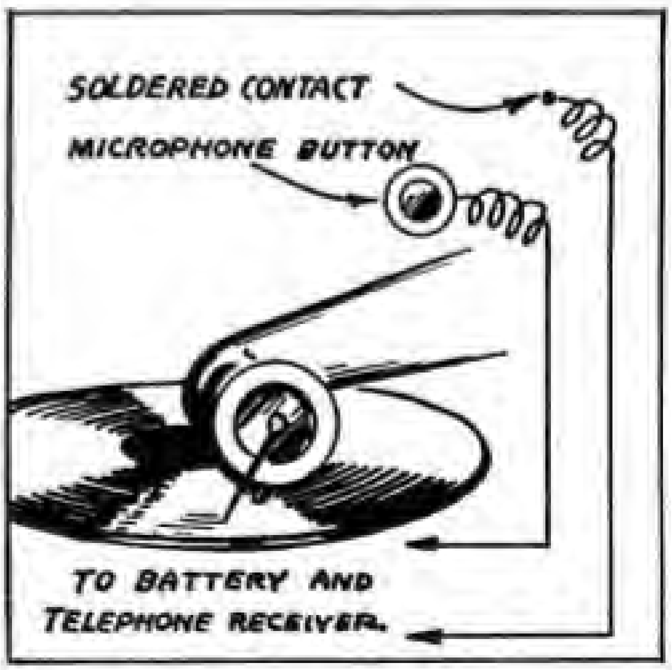




Talking Light

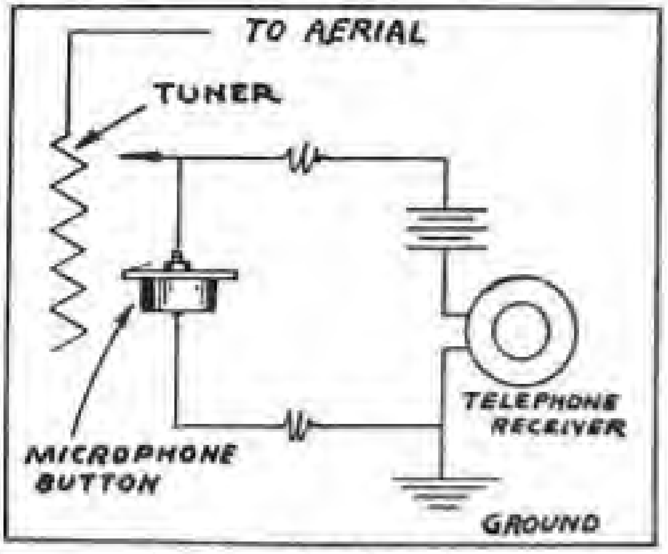
A simple experiment to sh_w how impulses may be transformed into different media. The sound waves are transformed to electrical waves by the Microphone Button. The electrical waves are transformed to light waves by the bulb. If you had a Photoelectric Cell (or Electric Eye), the fluctuations in the amount of light given off by the bulb could be used to actuate another circuit. Thus, by a spoken command you could have a door open or a window shut or a bell ring. (See also Relay Circuit).

If ordinary flashlight cells are used, a 3 volt flashlight bulb is sufficient.



Phonograph Pick Up

The music or talking from a phonograph can be readily picked up by means of a Microphone Button attached to the tone-arm of the phonograph. The front electrode of the button must be soldered or firmly attached to the arm. Ordinary telephone hook-up circuit is used. Or, the button can be wired directly to an amplifying circuit (see the Radio Hook-up) and played over loudspeaker, or even broadcast.



The Button As a Radio Detector

The Microphone Button can be used as a Radio Detector to pick up broadcast programs when used in the manner illustrated above. For loudspeaker volume, a more elaborate circuit has been devised which is described elsewhere.

Secret Detectaphone

Perhaps the most difficult application of the Microphone Button, yet one of its best uses, is as a Detectaphone. It requires maximum sensistivity and complete freedom from external interruptions.

The standard Telephone Hook-up is used, but an additional battery should be added, to make certain that strong current supply is fed into the circuit.

Where possible the largest sized diaphragm or sounding board should be used. The Microphone Button mounted in a tin can (see Stethoscope) and placed firmly against a table gives a good pick up. The table acts as a sounding board, and the tin can is a very receptive shape for picking up sound waves.

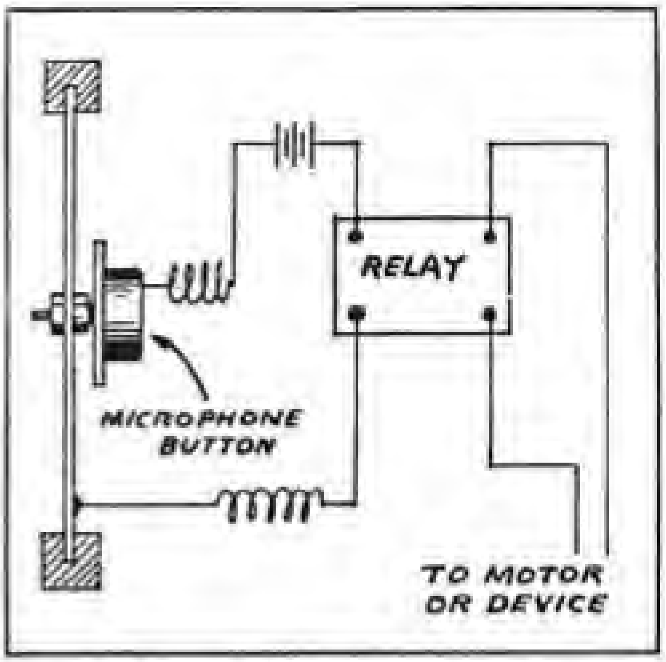
There are many other ways in which the button can be concealed, two of which are illustrated here. Oftentimes a framed picture offers the best location. It must be kept in mind, however, that the button should be located as close to the source of the talking or noise as possible in order to get maximum results.

IMPORTANT: Good, continuous wire should be used. Any splices or connections should be soldered.

Electric Musical Instruments

Most people have heard the "electric" guitar and other novelty electric musical effects. These are all created the same way. A microphone pick-up unit is connected to the sounding board of the instrument and wired to an amplifying unit or radio. Almost any musical instrument can be used.

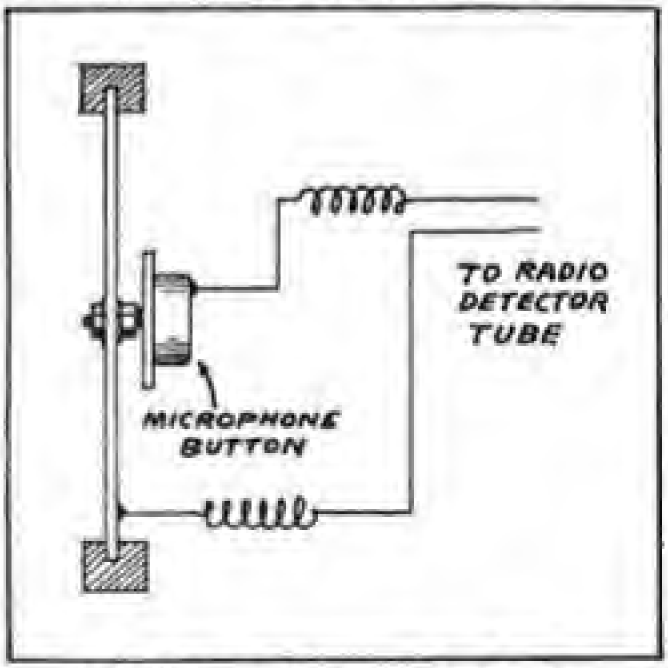
When using your radio for amplifying circuit, the button is connected directly to radio detector tube. (See Radio Mike). For best results, it will be necessary to try out the microphone button in several places on the musical instrument.



Doors Open and Mysterious Things Happen At Your Spoken Command

When use of a relay circuit, you can by means of a spoken command, make a window open, doors close, lights go on or off and many other things. You are only limited by your imagination and facilities as to what you can do.

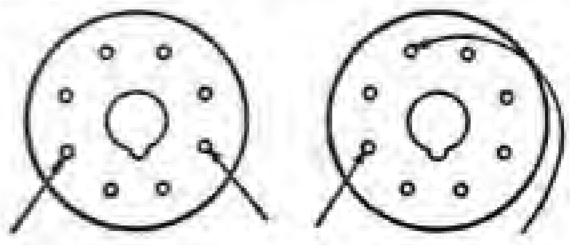
The circuit is quite simple. It merely consists of connecting the button to one side of a relay. A spoken command causes the amount of electricity in the button circuit to change, which in turn operates the relay. This closes or opens a second circuit which contains the motor or mechanism which opens doors, etc. If a light bulb is connected in this second circuit, it is turned on or off.



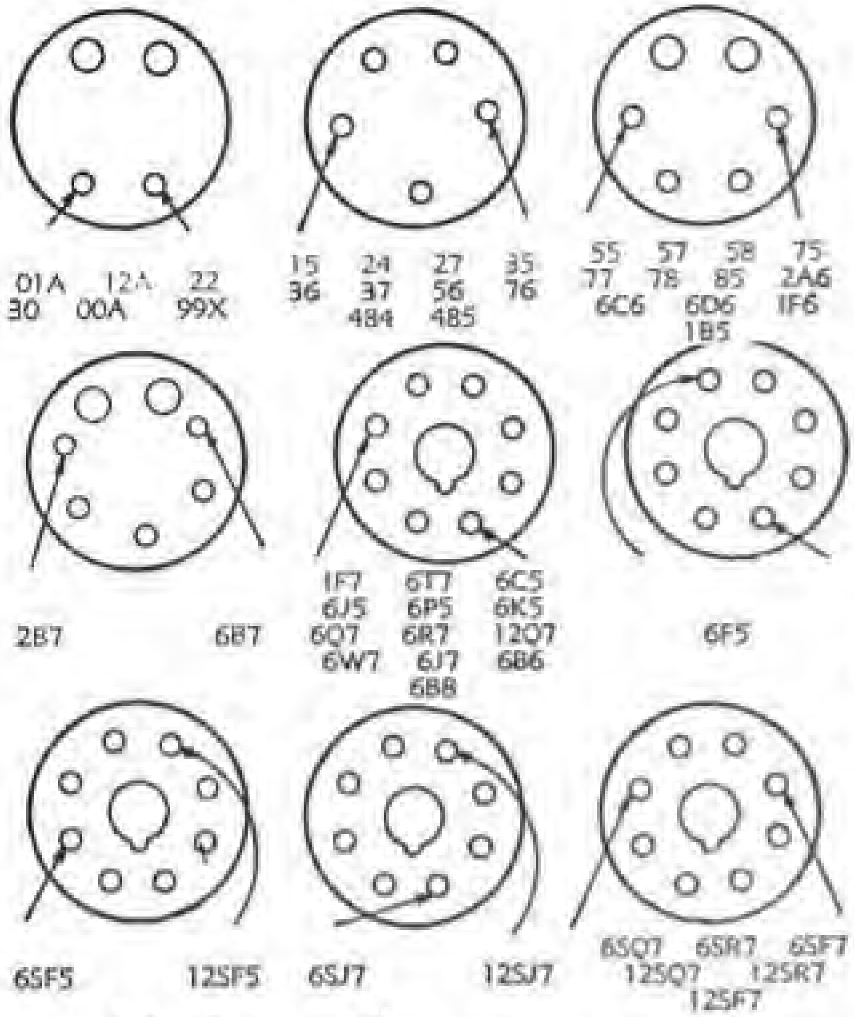
Radio Mike---Talk Through Your Radio

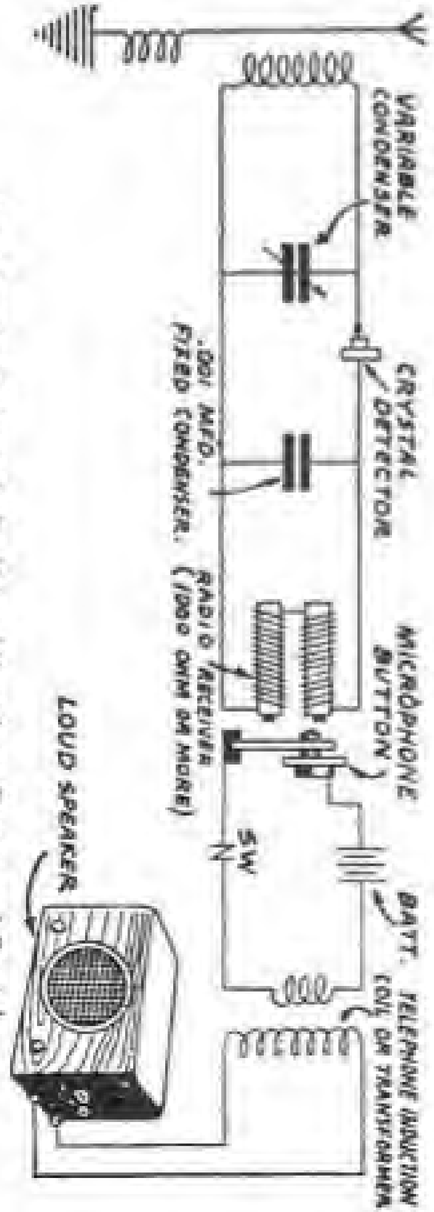
Microphone Button is connected directly to detector tube of radio. Locate detector tube from tubes listed here or with help of radio serviceman. Shut off set. Remove detector tube. Hold tube in hand with prongs pointing up. This corresponds to base of tubes illustrated here. Twist wires tightly around correct prongs as designated in diagram. Insert tube in set. Be sure that bare part of wire does not touch any other prong or any metal of set. If mike fails to operate reverse wires. Before using any tubes not listed here, consult your radio serviceman.

7A4
7B4
7C7
7E7
7R7
14A4
14E7
14R7



7B6
7C6
7E6
14B6
14E5

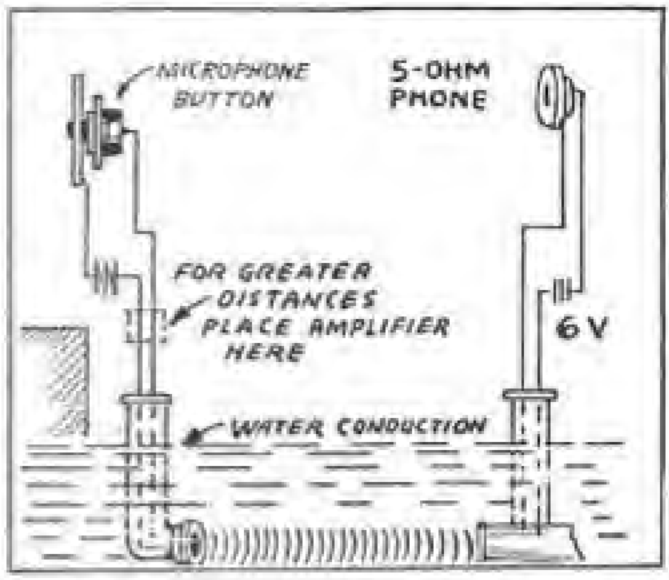




Loud Speaker Volume Radio Using Microphone Button and Crystal

This is an unusual type of radio that produces loud speaker volume, yet uses no radio tubes or "B" batteries. The diagram shows the essential features of its construction.

The Microphone Button is secured to the center of the earphone diaphragm. It is preferable to use a low resistance speaker, but if this is not available, a standard speaker can be used with additional batteries.



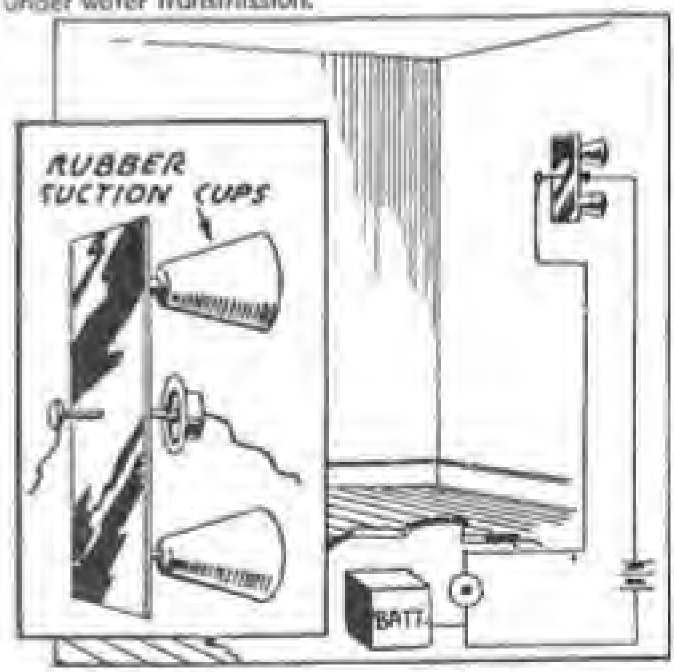
Sound Through Water---Submarine Telephones

This consists of two units. The transmitter (or broadcasting) and the receiver (or the sub-sea ear). Each unit uses a microphone button and a receiver.

The transmitter consists of an ordinary telephone hook up, with the receiver under water. The receiver must be protected from the water by wax, yet the diaphragm must be exposed to the water in order to transmit the sound waves.

The receiver also consists of an ordinary telephone hook up, with the microphone button under water. It is protected from the water by soldering it to the bottom of the inside of a tin can. The leads to the button should be protected from water.

This unit is only suitable for short distances. Longer distances---up to about 100 feet--- can be set up if an amplifying unit is used in the transmitter along with a loudspeaker instead of an earphone for the under water transmission.



Listening Through Walls

It is well known that when a person places his ear against the partition, he can hear the entire conversation in an adjoining room; provided that the conversation is loud enough and that the wall itself is not sound-proof. This position is tiresome both for the listener and unpractical for detective work. The apparatus consists of a small plate of metal, brass or the like, to which two rubber suction cups are attached as indicated. The transmitter button itself is mounted at the end of a long screw with a thumb or knurled nut for adjustment. In operation, the rubber suction cups are moistened with a little glycerine to make them adhere more firmly to the rather porous wall to which they are to be attached. After the suction cups are firmly in place, the thumb nut is turned to the right until the button just touches the wall. The receiver, which in this case is a 5 to 75 ohm receiver, reproduces the sounds with the proper degree of accuracy. A 4 to 6 volt battery is placed in the circuit and the detective operating the device can sit at a desk and copy down the entire conversation in the otherwise protected room. This form of eaves-dropping is more legitimate than installing detectophones in suspect's room.

Chambers' Encyclopaedia 1891

There have been several comments on the Chamber's Encyclopedia section; mostly uncomplimentary. The most common complaint is that the same information can be obtained from more modern encyclopedias in a more comprehensive and updated version. For the layman's purpose, this is simply not so. Modern encyclopedias are written mainly as introductory reference material. It is supposed that one with an interest in various chemical compounds and technical subjects need only the basic introductory material and so will go elsewhere for the working details. For this reason, the modern encyclopedias are sketchy in their descriptions or so technical that one must already be well grounded on a subject to profit from the modern encyclopedia's description.

The writers of the older encyclopedias, however, operated on the principal that theirs were the only descriptions of the subject the reader would have access to. So their entries were far more comprehensive than are the modern texts. Further, they operated on the principal that although the interested reader might be ignorant of the subject, he ought to be able to understand it if he could read at all. Therefore, entries were written so that any literate reader could duplicate the compound described whether he had any former familiarity with the compound or not.

You have but to compare a subject written in Chambers' 1891 Encyclopedia with a modern encyclopedia to see that the former was written for someone like you, rather than for one who was considering the subject for further study or already had some education in it.

In short, the older version is simpler, more complete and more applicable to the needs of the layman who may never see another reference to the subject.

KURT SAXON

CONTINUED FROM SURVIVOR Vol. 1, PAGE 403

Cautery (Gr. *kaio*, 'I burn'), in Medicine, is used of any substance which burns the tissues. (The term 'potential cautery,' as applied to caustic substances, is becoming obsolete.) The *actual cautery* is an instrument with a head or blade of steel, iron, or platinum, which is heated in a fire or spirit-lamp. In the *thermo-cautery* (or Paquelin's cautery, from its inventor), the head or blade is made of hollow platinum, so arranged that a flame of benzole can be kept burning in its interior. The *galvano-cautery* consists essentially of a platinum wire which can be heated to any required degree by passing a strong galvanic current through it. The cautery is used for three main purposes in surgery: to *produce counter-irritation* over an inflamed part (see BLISTER) (actual cautery); to *check bleeding* (actual or thermo-cautery), by slowly destroying the tissues at the bleeding point or surface; to *perform operations*, where the tissues to be divided are either very vascular (thermo-cautery), or very difficult of access (galvano-cautery). See CAUSTIC.

Cel'andine is the popular name (and corruption) of *Chelidonium majus*, a perennial papavera-

Celandine (*Chelidonium majus*):
a, a flower.

ceous herb, which, although not uncommon in Britain, is doubtfully indigenous. Its pretty foliage

Lesser Celandine (*Ranunculus Ficaria*).

and umbels of small yellow flowers, which bloom from May to August, might alone attract attention, but its ancient repute among herbalists is due to its yellow milky juice, which is very acrid and poisonous. Externally it was applied to warts and ulcers, and internally administered, it was supposed to be a specific for jaundice, apparently on no better warrant, however, than that drawn from its colour by the 'doctrine of signatures.' Its old English name Swallow-wort, which appears to be almost a translation of the botanical one, seems founded on a supposed association between the beginning and ending of its flowering time and the arrival and departure of the swallows.—It is, however, the LESSER CELANDINE which is more familiar to general readers, at least since Wordsworth devoted no fewer than three poems to its honour. This is *Ranunculus Ficaria*, also known as the common fig-wort or pile-wort, a quite unrelated ranunculaceous plant, which grows in abundant patches in fields and coppices, and brightens them in early spring with its plentiful golden flowers. Its tuberous roots and swollen separable buds give it additional botanical interest, while it is also noteworthy that these results of peculiarly vegetative habit are associated with a frequent imperfect maturity of the pollen.

Celluloid, or PARKESINE. This substance was first made by Mr A. Parkes of Birmingham in 1855 or 1856. It chiefly consists of a dried solution of gun-cotton (pyroxylin), or of what is nearly the same thing, and oil. A variety of it can be made with pyroxylin and camphor. It resembles ivory, horn, tortoiseshell, and hardened india-rubber, as regards certain properties.

The pyroxylin is prepared by treating Cellulose (q.v.) from such vegetable materials as cotton or flax waste, rags, paper-makers' half-stuff, or paper itself, with a mixture of one part of strong nitric acid and four parts of strong sulphuric acid. It is convenient to call the product so obtained pyroxylin, although the two things are not quite identical. The distillate obtained by distilling wood naphtha with chloride of lime is used as a solvent for the pyroxylin, but other solvents, such as nitrobenzol or aniline, and some camphor are added with advantage. When the excess of solvent is removed from the pyroxylin, it is mixed with a considerable quantity of castor-oil or cotton-seed oil, and made into a dough or paste between heated rollers. For a hard compound the quantity of oil should be less than the pyroxylin, for a soft one it should be greater. Chloride of sulphur is sometimes added to the oil. When articles made of celluloid are in a partially manufactured state, they are soaked in bisulphide of carbon or chloride of lime to remove any trace of solvent, which would render them apt to shrink if allowed to remain. Celluloid is of a somewhat combustible nature unless the substances used to colour it are such as will neutralise this, or unless some non-combustible chemical, tungstate of soda for example, is added to it.

Properties and Uses.—Celluloid has many valuable properties. It is buff or pale brown in colour, but it can be made as white as ivory, which it much resembles, or manufactured in a transparent state. It can be moulded or pressed into any form, and turned, planed, or carved. Neither the atmosphere nor water affects it. It is elastic and can be united by its own cement. In a plastic condition celluloid can be spread on textile fabrics, or it may be made as hard as ivory, for which it is largely used as a substitute. Billiard-balls, piano-keys, and combs are made of it, the latter two articles extensively. It can be coloured to represent amber, tortoiseshell, or malachite. In imitation of red coral it has been a good deal used for jewelry. Like vulcanite, which it excels in durability but exceeds in price, it has very numerous applications. We need only mention brush-backs, knife-handles, buttons, napkin-rings, card-cases, thimbles, and dolls. It is useful for optical instruments and for some surgical instruments. One of the most recent applications of it is for shirt fronts and collars. The manufacture of celluloid, although an English invention, has been most largely developed in the United States, where it is mostly, if not entirely, made by one firm, the Celluloid Manufacturing Co., Newark, New Jersey, who use this word as a trade-mark.

Cellulose is the substance secreted by the living protoplasm of a vegetable cell to form its investing membrane or cell-wall. (See CELL, and HISTOLOGY, VEGETABLE, for account of its mode of formation, its ligneous, corky and colloid change, its mode of arrangement and union in cell-walls, &c.). It is obtained in a pure state by treating any unaltered cellular tissue with alkalies and acids to remove mineral matter and protoplasm, and successive washings with water, alcohol, and ether to remove soluble substances. Cotton-pith or vegetable-ivory, although much contrasted in histological properties, are alike remarkably pure cellulose. Cellulose has the chemical composition $C_6H_{10}O_5$, and spec. grav. 1·52. Among its familiar natural modifications gum is an isomer, and starch-dextrin and grape-sugar are all of similar ultimate composition, while its woody and corky modifications (lignin and suberin) possess an increasing proportion of carbon. Iodine alone stains cellulose yellow or brown, but blue when strong sulphuric acid has been previously added. Strong hot sulphuric acid chars it, while brief immersion in the cold converts it into a tough and dense modification, well known in parchment paper, and prolonged treatment dissolves it altogether. Dextrin may thus be prepared and next transmuted, by boiling the watery solution, into grape-sugar (see DEXTRINE, GLUCOSE). By immersion in a mixture of strong nitric and sulphuric acid we obtain Gun-cotton (q.v.), while dilute nitric acid or potash oxidises it into oxalic acid. Ammoniacal oxide of copper dissolves it without change, as is shown by its reprecipitation on dilution. By heating in closed vessels under pressure a dense coal-like mass is formed, while in ordinary dry distillation, gas, tar, and acetic acid are given off, processes which throw light on the formation of coal in nature and on the chemistry of gas-making. In natural decomposition cellulose turns yellow and brown with gradual formation of humus.

Although so constant and characteristic a product of vegetable life, the conditions and mode of its formation are still very obscure. From that cell-cycle or rhythm of change between the passive and cellulose-walled state and an active and wall-less one, which is so characteristic of the lowest forms of life, and of which we find surviving traces (e.g. the rejuvenescence of the pollen-grain) in the reproductive processes of even the highest plants (see CELL), it would appear that there is some relation between this increased passivity and the formation of cellulose. And in this way arises the speculation that cellulose may be viewed essentially as a (mechanically coherent and thus useful) excretion, an incompletely utilised waste product corresponding to the carbonic acid and water given off by the completer respiratory oxidation and larger evolution of energy of the active phase. Once formed by the plant, it may be again absorbed, as is well seen in the union of a row of cells into a continuous vessel, or in the consumption of endosperm of a seed during germination. Many seeds, such as vegetable-ivory or date, have a great proportion of their reserve material in this form; and this must be digested into glucose by the growing embryo, and again worked up into new protoplasm, which deposits cellulose as before. Like the plant itself, the similar digestive ferments of the animal might thus be naturally expected to digest cellulose; and this is actually, to some extent, the case with the delicate young cell-walls of many green vegetables, as can be experimentally verified, even in man; while in herbivorous animals this power is much developed, and the nutritive utilisation of their fodder is thus increased to an important extent.

The cysts of amœbæ and other protozoa appear to be at least largely composed of cellulose, and the external tunic of ascidians (see TUNICATA) is of identical, or at least isomeric, composition. Cellulose has been described as a pathological product, even in brain-tissue; and Chitin (q.v.), a very characteristic and in many respects comparable animal product, has been sometimes viewed as cellulose in association with a proteid substance.

Cements. These may be roughly divided into three classes: (1) The stone cements, including Roman and Portland cements, and ordinary mortar, which are used in thickish layers for uniting stone and brick work, and for protective coverings to buildings; (2) substances which form binding joints of much less but still appreciable thickness, such as white lead, red lead, and putty; and (3) cements which require to be used in extremely thin coatings, such as glue, isinglass, and dissolved caoutchouc.

Ordinary Mortar is a mixture of slaked lime (*calcium hydroxide*) and sand, made into a paste with water. Generally one part of lime to three or four parts of sand are used, but the proportions vary according to the purity of the lime employed. Very pure or fat lime, such as that made by burning white chalk or white marble does not make so good a mortar as lime obtained from less pure limestones, which are by far the most abundant. The more thoroughly the ingredients are intermixed, the more complete will be the subsequent hardening of the mortar. As commonly laid in the joints of brick or stone work, mortar sets sufficiently fast to allow building operations to proceed from day to day with occasional longer intervals, but it takes years—perhaps in many cases centuries—to reach its maximum hardness. The setting and subsequent slow hardening of mortar are usually considered to be due, in the first instance, simply to the loss of water, and afterwards to the absorption by the lime of carbonic acid from the atmosphere, the carbonate of lime thus formed binding together the sand and stone. It is doubtful, however, if this is an altogether satisfactory explanation. The mortar used in many medieval buildings is largely mixed with small pebbles. In a number of cases this has proved to be of a more durable nature than the stone used along with it.

Puzzolana or *Pozzuolana*, a loosely coherent volcanic sand found at Pozzuoli, near Naples, has been long celebrated for its property of forming a hydraulic cement when mixed with ordinary lime. It is composed of silica, with a little magnesia and potash or soda, alumina, lime, and oxide of iron.

Roman Cement.—Certain natural mixtures of lime and clay are called cement-stones. The clays of some of the newer geological formations in the south of England, for example, contain courses of septarian nodules (see SEPTARIA), which have been in great request for making the best kinds of Roman cement. They are concretions of impure calcareous matter, many of them having this analysis: Carbonate of lime, 66; silica, 18; alumina, 7; and protoxide of iron, 6; or consist of these substances in nearly that proportion. Cement-stones are carefully calcined in kilns, and afterwards ground and sifted. Good Roman cement should set in about 15 minutes, and this quick-setting property makes it valuable for work which requires to be executed between tides and for other purposes where the cement used must harden quickly. It is at best of but medium strength. Some natural cements are slow-setting, and these do not contain more than 22 per cent. of clay. They set under water when half their weight consists of clay. The proportion of sand used with Roman cement should not much exceed that of the cement. When employed for external coatings of buildings it is apt to effloresce and become unsightly.

Portland Cement.—This is considered by far the most important of the stone cements. It is an artificial product, named from its resemblance to Portland Stone, but is much more largely used than Roman cement. In the manufacture of Portland cement on the banks of the Thames and the Medway by the wet process, three parts of white chalk are mixed with one part of clay or mud from the lower reaches of these rivers. The two substances, along with water, are placed in a 'wash mill' in which strong revolving knives or cutters reduce the whole to a creamy 'slurry' or slip. The slurry then passes by gravitation to backs or reservoirs. There it is allowed to settle for some weeks, when the superfluous water is removed by decantation. The mixture is next dried on heated iron plates or on the floor of a heated chamber, and then burned in kilns. Finally it is ground to a fine powder. Modifications of the wet process by which the large reservoirs are dispensed with have been introduced in recent years. In other parts of the country Portland cement is manufactured by the dry process from the hard limestones of other formations than the chalk, along with clay or shale. These limestones are crushed small, mixed in the proper proportion with clay or shale, then roughly burned, and ground to powder. This powder slightly moistened is passed through a pug-mill, and then made into bricks, which are afterwards burned in kilns and reduced to powder.

Since Portland cement is hardly ever employed in the pure or neat state, its strength is perhaps best tested when it is mixed with an equal weight of sand. The best cement so mixed and moulded in the state of a stiff mortar, into any convenient shape, when tested after the lapse of seven days, during six of which it is customary to keep it immersed in water, exceeds in tensile strength 200 lb. per square inch, and in crushing strength, tested by 1½-inch cubes, 1000 lb. for the same area. Its strength in the unmixed state is much greater. Much of the Portland cement made is, however, little more than half as strong as the best kind. Roman cement of good quality mixed to the same extent with sand as the above, and tested under the same conditions, has on an average a tensile strength of 30 lb., and a crushing strength of 200 lb. in each case per square inch. Portland cement is slow in setting compared with most varieties of Roman cement. Both Portland and Roman cement form *hydraulic mortars*—that is, they set under water. No mortar will do this which contains less than 10 per cent. of silica.

Till close on 1840 Portland cement was hardly known, but the use of it has extended rapidly, especially in recent years. Its most important application is in the construction of docks and harbours, many of which are partly or wholly built of it, mixed with sand and broken stones, in the form of a concrete. In this state, or simply mixed with sand, it is also much employed for other purposes where strength and durability are required. Owing to the nature of some of the extensive engineering works in which Portland cement is largely used, it is plainly of great consequence that its properties should be thoroughly understood. Numerous failures with it have taken place. The chemical investigation into the case of the Aberdeen docks in 1887 distinctly showed the deleterious action of sea-water upon this substance. But it is also known that objects made of unmixed Portland cement from the works of some of the best makers will sometimes keep good for nearly twenty years, and then crumble to pieces even when not exposed out of doors at all. Of course explanations of these failures are forthcoming. They are generally attributed to carelessness in the manufacture of the cement, or in the selection of the materials for it. But if they occur, as they have done, with cements that have stood very well the ordinary mechanical tests, how can any cement of this kind be entirely depended upon for durability? Twenty, thirty, or even fifty years is far too short a time to test the lasting property of a building material of this nature. The use of Portland cement in pavements and for architectural ornaments is not attended with much risk, and for such purposes it is very suitable. The capital employed in the manufacture in Great Britain is probably near two millions sterling. For American cements, see ROSENDALE.

Scott's Selenic Cement consists of burnt limestone mixed with about 5 per cent. of sulphate of lime in the form of plaster of Paris, and ground to powder. The presence of the sulphate arrests the slaking action of the lime, causes the cement to set more quickly, and admits of more sand being used with it than ordinary lime does. This cement has been a good deal used for plastering, and to some extent also for mortar.

Plaster of Paris (see ALABASTER and GYPSUM).—This material is used for cementing marble and alabaster in much the same way as mortar is in brick-work. It is also employed for uniting the separately moulded pieces of any large object cast in the same material. Sometimes it is selected for fixing metal mounts to glass.

Keene's Cement is made by saturating plaster of Paris in small lumps with alum and recalcining it. It then forms a hard plaster for the projecting portions of halls and rooms, such as pilasters, columns, and skirtings. It is capable of taking a high polish.

Parian or Keating's Cement somewhat resembles Keene's. In its manufacture borax as well as alum is added to the plaster of Paris.

Martin's Cement is another kind, with plaster of Paris for its basis, but instead of borax, carbonate of potash is added, and sometimes hydrochloric acid as well. With the exception of Scott's, these plaster of Paris cements are only used in plastering or other internal work—not for mortars.

Mastic Cement, consisting of a mixture of burnt clay or limestone in a powdered state, with boiled oil and litharge, was more in use formerly than now; but though expensive, it is an excellent material for preventing the admission of rain-water at certain joints about buildings, such as where wood and stone work come together at windows. It was also used for covering external mouldings.

Rust or Iron Cement.—Joints in iron-work, such as those for hot-water pipes, are filled up with a cement of iron borings or turnings, mixed with at least 2 per cent. of sal-ammoniac. Sometimes sulphur in powder is added. The iron oxidises and forms a firm joint.

Sulphur Cement.—For jointing earthenware pipes, and occasionally for fixing bars of iron into stone, a cement is made of sulphur, resin, and brick-dust. It is a cheap but not a strong cement where metal is concerned.

Water-glass Cements.—For furnaces one kind consists of burnt and unburnt fireclay made plastic with silicate of soda or water-glass. Another cement, capable of standing a high heat, is formed of asbestos powder made into a paste with silicate of soda. The same silicate mixed with ground glass makes an acid-proof cement.

White and Red Lead Cements.—Either white lead or red lead by itself, or a mixture of both, is much in request as a cement for the joints of slate or glass cisterns, such as aquariums. These are also employed for the joints of gas-pipes, for cementing metal mounts to glass tubes, and other chemical and electrical purposes. White and red lead cements are made up with boiled linseed-oil, and sometimes gold size is added. Mixed white and red lead make a very hard and firm cement. A cement of these two substances and ground plumbago in equal parts, mixed with oil, is said to stand a great heat in steam-joints.

Shell-lac Cements.—An excellent cement is made by digesting 4 oz. of the finest shell-lac in 3 oz. of methylated spirit in a warm place. It should be made into a consistency like thick syrup. This makes a firm cement for mending pieces of glass, china, ornamental stones, and ivory. It is not soluble in water. A cheaper, but still very serviceable cement can be formed by dissolving shell-lac in wood naphtha. For some purposes shell-lac itself is used as cement by simply melting it.

Marine Glue is a mixture of shell-lac in a solution of india-rubber. It is made into thin sheets, and melted when required for use in shipbuilding, &c.

Gelatin and Isinglass Cements.—Fish-glue, gelatin, or isinglass (q.v.), made up with dilute acetic acid and other bodies into a jelly or thick liquid, produces a cement slightly varying in its nature, for mending china, glass, ivory, bone, and other substances. Foulke's cement and liquid fish-glue are cements of this class. These can be obtained in a convenient form for use in hardware or druggists' shops. They are more or less soluble in water, so that articles mended with them must be quickly washed. Cement of mixed glue and glycerine, sometimes with tannin added, is occasionally used for leather and cloth.

Armenian or Diamond Cement.—The following is the reputed formula for preparing the cement used by the Armenian jewellers for attaching diamonds, &c., without any metallic setting: 'Dissolve five or six bits of gum-mastic, each the size of a large pea, in as much rectified spirit of wine as will suffice to render it liquid; and in another vessel dissolve as much isinglass, previously a little softened in water—though none of the water must be used—in French brandy, or good rum, as will make a 2-ounce phial of very strong glue, adding two very small bits of galbanum or ammoniacum, which must be rubbed or ground till they are dissolved. Then mix the whole with a sufficient heat. Keep the glue in a phial closely stopped, and when it is to be used, set the phial in boiling water.'

Elastic Cements.—One part of caoutchouc dissolved in 3 parts of chloroform; also, 5 parts of caoutchouc in 3 parts of chloroform, with 1 part of powdered gum-mastic added. Benzole is sometimes used instead of chloroform as the solvent. Another elastic cement can be made by a mixture of gutta-percha and caoutchouc dissolved in bisulphide of carbon. The solvents of these cements must not be exposed to any but a gentle heat.

Resin Cements.—There are a great number of cements partly formed of ordinary resin. One kind consists of resin 4, beeswax 1, and whiting 1 part. The proportions of these ingredients in the same order for another are 15, 1, and 4. Another is made from resin 4, and plaster of Paris 1 part. These cements are used to fix pieces of stone, glass, &c. to handles when grinding them. Resin, pitch, beeswax, and plaster of Paris or brick-dust are made up in various proportions into cements.

Cutlers' Cement, used for fixing knives and forks in handles, is made of equal weights of resin and brick-dust melted together; or, for a superior quality, 4 parts of resin, 1 of beeswax, and 1 of brick-dust.

Copal varnish, mastic varnish, Canada balsam, and gold size are each useful occasionally for cementing substances like two pieces of glass together.

Cerebro-spinal Fluid is a clear, almost colourless, slightly alkaline fluid, closely resembling lymph in its composition, but containing less albumen. It is contained partly within the ventricular system of the brain, and in part in the loose connective tissue (subarachnoid meshwork), which lies between the Arachnoid and Pia Mater (q.v.), being continued from this latter situation along the lymphatic sheaths, which closely invest all the blood-vessels in the substance of the brain and spinal cord. The spaces which contain it communicate with the lymphatics of the head and of the nerves, and with the venous sinuses in the dura mater. Its main function, besides that of removing waste products, is to equalise the pressure within the skull. As the blood pressure increases that of the cerebro-spinal fluid diminishes, and *vice versâ*. As the brain atrophies it is replaced by a proportionate increase in the fluid. In some diseases, such as acute and chronic Hydrocephalus (q.v.), it is greatly increased, and then it becomes a cause of atrophy of the brain. Its value as a water-cushion in diminishing the violence of shock from external injury has been already referred to at BRAIN. *Cerebro-spinal* means pertaining to the brain and spinal cord together, to the cerebro-spinal system.

Cerium (sym. Ce, eq. 92) is a rare metal found in cerite and a few other minerals. It is a white metal, has not been obtained in any quantity, is not therefore employed in any manufacture, and forms two basic oxides and a numerous class of salts. The nitrate and oxalate of cerium have been employed in the vomiting of pregnancy, their action being somewhat similar to that of the subnitrate of bismuth. Cerium biscuits are biscuits containing a small proportion of the oxalate, and they form a very convenient medium for the administration of the salt. *Cerite* or *Ochroïte* is the silicate of cerium, and is found as a mineral in gneiss, near Riddarhytta, in Westmanland in Sweden.

Ceru'men is ear-wax, the yellow waxy matter which is secreted by certain glands lying in the passage that leads from the external opening of the ear to the membrane of the tympanum. It lubricates the passage and entangles particles of dust and small insects, preventing them from getting farther in.

Chalaza. The first layer of albumen deposited upon the yolk of an egg as it descends the bird's oviduct, is peculiarly viscous, and thus becomes twisted into two strands which keep the yolk in the middle of the more fluid albumen. These cords are also called *chalazæ*.

Chalk, a soft earthy variety of limestone or carbonate of lime, forming great strata, and claiming the attention of the geologist even more than of the mineralogist (see CRETACEOUS SYSTEM). It is generally of a yellowish-white colour, but sometimes snow-white. It is easily broken, and has an earthy fracture, is rough and very meagre to the touch, and adheres slightly to the tongue. It generally contains a little silica, alumina, or magnesia, sometimes all of these. Although often very soft and earthy, it is sometimes so compact that it can be used as a building-stone; and it is used for this purpose either in a rough state, or sawn into blocks of proper shape and size. It is burned into quicklime, and nearly all the houses in London are cemented with mortar so procured. The siliceous particles being separated by pounding and diffusing in water, it becomes whiting, of which the domestic uses are familiar to every one. Carpenters and others use it for making marks, which are easily effaced: the *blackboard* and piece of chalk are now common equally in the lecture-rooms of universities and in the humblest village-schools. Chalk, perfectly purified, is mixed with vegetable colouring matters, such as turmeric, litmus, saffron, and sap-green, to form pastel colours or coloured chalks; but vegetable colours which contain an acid are changed by it (see CRAYON). The *Vienna white* of artists is simply purified chalk. In a perfectly purified state it is administered as a medicine to correct acidity in the stomach. Chalk is also extensively used as a manure. See LIME, MANURE.

BLACK CHALK is a mineral quite different from common chalk, and apparently receives its name from resembling it in meagreness to the touch, in soiling the fingers, and in being used for drawing, writing, &c. It is also called Drawing-slate. It is of a slaty structure, of a bluish or grayish-black colour, easily cut and broken, and makes a perfectly black mark on paper. It is used for drawing and as a black colour in painting. It becomes red by exposure to heat. It is essentially a kind of Clay (q.v.), and derives its colour from carbon, which it contains. It is found associated with schists, &c. in Spain, France, Italy, &c., also in the coal formation in Scotland.—BRIANÇON CHALK and FRENCH CHALK are popular names for Soapstone (q.v.).—RED CHALK is *ochry red clay-iron ore*, consisting of clay and much peroxide of iron. It is of a brownish-red colour, and a somewhat slaty structure, the cross fracture earthy. The coarser varieties are used chiefly by carpenters for making marks on wood; the finer, by painters. It occurs in thin beds in clay-slate and graywacke-slate in some parts of Germany.

Chara. The Characeæ or Stoneworts are a small group of common aquatic plants found growing in large tufts, or even covering large expanses on the bottoms of fresh-water ponds and shallow lakes, brackish or even salt-water lagoons, &c., and of which the systematic position has undergone the most extraordinary and instructive vicissitudes. The early botanists, with K. Bauhin, had no hesitation in describing them as horsetails (Equisetum). In 1719 Vaillant proposed for them a separate genus (Chara), while Linnæus, although at first disposed to regard them as Algæ, as their habitat suggests, decided that the small red male reproductive body must be a stamen; and the larger green female one a pistil, and accordingly placed them as flowering plants among the *Monoecia Monandria*. His pupils at most ventured to remove these to the *Monandria Monogynia*, while De Jussieu regarded them as a genus of Naiadaceæ (q.v.), an order of monocotyledonous aquatics with much reduced flowers. In similar opinions he was followed by De Candolle and other eminent systematists; and it was not until 1851 that a careful re-examination of their structure and mode of reproduction by Thuret finally disproved the phanerogamous view, and established their cryptogamic nature. Since that time the group has attracted great attention, and is now on grounds of peculiar instructiveness, both morphological and physiological, one of the classical forms usually presented to the beginner, not only in cryptogamic botany, but general biology.

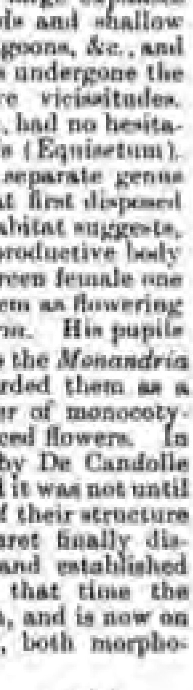


Fig. 1. Shoot of Chara.

Commencing with the vegetative system, we find this apparently consisting of a stem with regular whorls of leaves arising at definite points (nodes) of the stem. The internodes, or distances between these, are at first considerable; but as we approach the apex these are shorter and shorter, and at length we lose sight of them in the crowded terminal bud. The resemblance to a young shoot of Equisetum is so far satisfactory, and the mineral incrustation (in some species so abundant as to lead to the substitution of the plant for scouring metal) appears to confirm this. The incrustation, however, is calcareous, not siliceous. Even under microscopic examination we may at first sympathise with the old observers, and seem to see in the stem a multicellular structure, even a cortex; nay, to see under our very eyes the actual circulation of the sap. More careful scrutiny, however, enables us to repeat the work of later and more accurate observers. We see that this movement is not the circulation of the sap in a stem, but a streaming of the protoplasm within what is simply a single enormous cell stretching from one node to the next (see CELL). The apparent cortex is a single layer of cells covering this internodal cell; and the whole vegetative structure is unravelled when we roughly dissect out the terminal bud, harden, stain and imbed this in paraffin, and thus cut a fine longitudinal section (fig. 2). An apical cell is seen which continually segments off a lower one; this divides (still transversely to the axis) into two new ones; and the lower of these henceforth steadily lengthens as the internodal cell, while the upper undergoes repeated division, until a plate of nodal cells is formed. In the simpler family (Nitella) the internode thus consists of a single naked cell: in the higher (Chara), this is inclosed by the so-called cortex, a layer of smaller cells proceeding from those of the upper and lower nodes; and itself showing a minor nodal and internodal arrangement. In all cases, from the nodal cells there divide off, parallel to the outer surface of the stem, a new set of apical cells, which proceed, like the parent one, to form the 'leaves,' reproducing, that is to say, the stem structure, until they lose the power of division, and end in a single enlarged vegetative cell. A branch may arise from a new formed apical cell cut off in the axil of the oldest leaf of any whorl, while the so-called roots, which fix the plant in the mud, are simply unicellular hairs, lengthenings produced from the superficial cells of buried nodes.

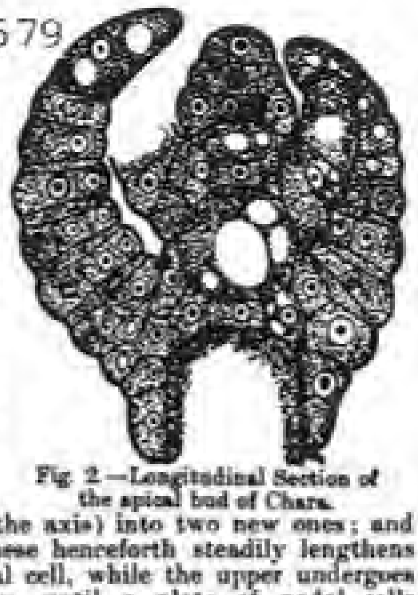


Fig. 2.—Longitudinal Section of the apical bud of Chara.

The apparently very complex and characteristic reproductive organs arise also at the nodes of the stem or leaves, in positions and numbers varying with the species. Commencing with the female (fig. 3*a*), which arises in the position of a branch, we find this to be obviously a shortened and modified one. Its apical cell forms only an internode and node, then ceases division, and becomes enlarged and filled with a store of starch and other reserve material to form an egg-cell; while the cover or archegonium inclosing this is readily seen to be a mere modification of the familiar cortex. In the male apparatus, or antheridium, the branch structure is further modified: its apical cell similarly remains all but sessile, forming only a short node and internode; but segmentation now begins, thus recalling the behaviour of a nodal cell—with which, in having below it an internodal, and not as in the case of the egg-cell, a nodal cell (fig. 3*b*), it so far corresponds. Eight quadrant-like cells are formed, but these now segment off new cells in the interior of the spherical mass, and in the growth and development of these the nodal and internodal alternation of ordinary vegetative growth can still be traced. Soon, however, a number of long segmented filaments are developed, and the protoplasm of these undergoes rejuvenescence, and becomes modified into a ciliated spermatozoid. When the reproductive organs are ripe, this archegonium is easily broken, and its filaments spread free in the water; the spermatozoids escape in a myriad, and some reach the egg-cell of the archegonium by means of a small opening, which is left by the all but incomplete upgrowth of the cortical cells which form the wall of the archegonium. After a period of rest, the fertilised ovum germinates, producing, however, not directly a new Chara plant, but a simple filament of cells called a pro-embryo, of which one cell segments into a node, and the oldest cell of this becomes the growing point of the new plant.

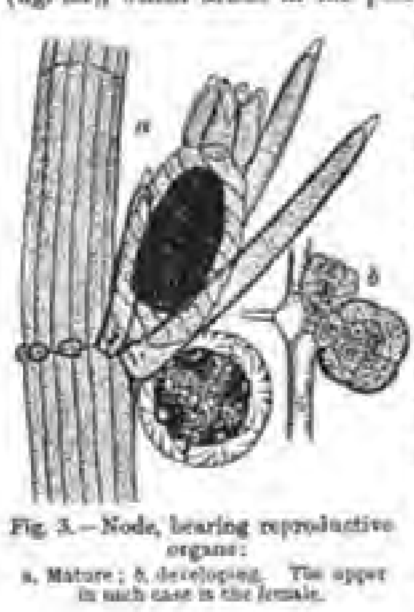


Fig. 3.—Node, bearing reproductive organs:
a, Mature; b, developing. The upper in each case is the female.

The affinities and systematic position of the group thus still afford ground for discussion, although now within narrower limits than formerly; some systematists regarding them as a somewhat aberrant group of Algæ, while others insist on their resemblance to the archegoniate cryptogams. (see VEGETABLE KINGDOM). The fruits of what seem to have been gigantic Characeæ (Spirangium) occur from the Carboniferous to the Wealden, and ordinary Characeæ are abundant in the Tertiary strata.

Charcoal is a term most frequently applied to charred wood, or coal produced by charring wood. Formerly, charcoal was the name for charred sea-coal or mineral coal; and the word is popularly used for the carbonaceous residue of vegetable, animal, or mineral substances when they have undergone smothered combustion.

ANIMAL CHARCOAL, BONE-BLACK, or IVORY-BLACK, is prepared from bones by heating them in close retorts till they undergo the process of destructive distillation, when combustible gases and water, together with the vapours of various salts of ammonia, and oil, are given off, and bone-black is left in the retort. It is generally reduced to coarse grains from about the size of small peas down to large pin-heads, and is extensively used in the arts for decolourising liquids, such as the syrup of sugar, and solutions of argol (impure cream of tartar) and of the alkaloids, as also in Filters (q.v.) for separating chemical impurities from water. The general mode of using the bone-black is to allow the coloured liquid to percolate through a layer of the charcoal, when all colour is arrested, and the syrup or water runs clear and colourless from under the stratum of charcoal. This power of absorbing colouring matters is also observable in vegetable (peat or wood) charcoal, but not to such an extent as in bone black. The application of heat to the liquids before filtration greatly facilitates the decolourisation, and where the volume of liquid to be operated upon is not great, the most expeditious method is to boil the liquid and bone-black together, and then strain through filtering-paper or cloth. The composition of bone-black in 100 parts is 10 of pure charcoal, associated with 90 of earthy salts—i.e. in the proportion of one of pure charcoal in 10 of the commercial bone-black. The power of absorbing colours appears to be due to the porosity of the substance, and is not resident simply in the pure charcoal; indeed, the earthy matters (principally phosphate of lime and carbonate of lime) can be dissolved out of the bone-black by dilute hydrochloric acid, and the pure charcoal thus obtained only possesses about one-third the decolourising power of the total amount of bone-black it was obtained from. Thus, if 100 parts of ordinary bone-black have the power of arresting the colour from *ten* volumes of a given coloured liquid, then the 10 parts of pure charcoal which can be obtained from the 100 parts of bone-black will be found to decolourise only *three* volumes of the same coloured liquid; so that it is apparent the earthy matters in the bone-black influence and increase the absorption of the colouring matter, and thus render a given weight of the charcoal of greater commercial value. When syrup of sugar and other liquids have been run through bone-black for some time, the pores of the latter appear to get clogged with the colour, and the clarifying influence ceases, and then the bone-black requires to undergo the process of *revivification*, which consists in reheating it carefully in ovens, or iron pipes inclosed in a furnace, when the absorbed colour is charred, and the bone-black can be of service once again as an arrester of colour. After several reburnings, the bone-black becomes of very inferior absorptive quality, and is then disposed of for the manufacture of bone-ash and dissolved bones (see BONE MANURES). Bone-black has likewise a great power of absorbing odours, especially those of a disagreeable nature, and can thus be employed to deodorise apartments, clothing, outhouses, &c., or wherever animal matter may be passing into a state of active putrefaction.

WOOD CHARCOAL is the most important, though not the purest kind of Carbon (q.v.). Wood consists of carbon, hydrogen, and oxygen, the last two being in the proportion to form water. When heated in the open air, it burns completely away, with the exception of a small white ash; but if the supply of air be limited, only the more volatile matters burn away, and most of the carbon remains. This is the principle of the process of charcoal-burning in countries where wood is abundant.

Billets of wood are built up vertically in two or three rows into a large conical heap, which is covered over with turf or moistened charcoal-ash, and holes left at the bottom for the air to get in. An open space is also left in the middle of the heap to serve as a flue. The heap is set on fire by putting burning wood into the top of the central opening. The combustion proceeds gradually from the top to the bottom, and from the centre to the outside of the heap; and as the central portions burn away, fresh wood is continually thrown in at the top, so as to keep the heap quite full. The smoke is thick and white when the process is going on properly; if it becomes thin, and especially if a blue flame appears, the wood is burning away too fast, and the combustion must be checked by closing the holes at the bottom, or by heaping fresh ashes on the top and sides. As soon as the combustion is completed, the heap is completely covered with turf or ashes, and left to cool for two or three days. It is then taken to pieces, and the portions still hot are cooled by throwing water or sand upon them. It is found that 100 parts of wood yield on the average from 61 to 65 parts by measure, or 24 parts by weight, of charcoal. The charcoal thus prepared is the best suited for fuel. In England a large quantity of charcoal is obtained in the dry distillation of wood in cast-iron cylinders, for the preparation of crude acetic acid. The charcoal thus prepared is preferable for making gunpowder, but is inferior for other purposes. A peculiar kind of charcoal of a reddish-brown colour, and hence termed *charbon roux* or *red charcoal*, is frequently prepared for the manufacture of the gunpowder used for sporting purposes, by subjecting wood in iron cylinders to the action of superheated steam under a pressure of two atmospheres. Powder made with this charcoal absorbs moisture more rapidly than ordinary gunpowder.

The general properties of wood-charcoal are, that it is black and brittle, and retains the form of the wood from which it is derived; it is insoluble in water, infusible and non-volatile in the most intense heat; its power of condensing gases is noticed under Carbon (q.v.); and from its power of destroying bad smells it has been regarded as possessing considerable antiseptic properties. It is frequently stated that charcoal is a bad conductor of heat, but a good conductor of electricity. These properties depend upon the nature of the charcoal, the lighter wood, such as willow, yielding a porous charcoal, with little power of conducting heat or electricity; while boxwood yields a very compact charcoal, which is a good conductor of heat and electricity, and is admirably adapted for the exhibition of the electric light. Charcoal never consists entirely of pure carbon, the degree of purity varying directly with the temperature at which it is formed; thus, charcoal charred at 480° (249° C.) contains 65 per cent. of carbon, while that charred at 750° (399° C.) contains 80, and that charred at 2730° (1499° C.) contains 96; but the loss of charcoal occasioned by these high temperatures is very great, the percentage yield of charcoal corresponding to these temperatures being 50, 20, and 15.

The uses of wood-charcoal are numerous and extensive. It is very largely employed as a fuel, taking the same place in many countries that coal occupies here. From its being proof against all ordinary chemical agencies, superficial charring is often employed to protect wood from decay, as in the case of fence-posts, of telegraph poles, or of piles which are driven into mud or into the beds of rivers to serve as foundations. With the same design it is not unusual to char the interior of tubs and casks destined to hold liquids. In a finely-divided state it is commonly regarded, as has been already stated, as an antiseptic; and there is no doubt that the offensive effluvia from animal matter in an advanced stage of putrefaction disappear when the putrefying substance is covered with a layer of charcoal; but in reality the decay goes on, without the emission of any odour, till at length the whole of the carbon is dissipated as carbonic acid gas, and the hydrogen as water, while the nitrogen remains as nitric acid. It has been shown that the action consists in a rapid process of oxidation, dependent upon the power which finely-divided charcoal possesses of condensing oxygen. In a finely-divided state, charcoal not only condenses gases to a marvellous extent, but has the power of absorbing colouring matters, bitter principles, &c.; and hence it is of extensive use in the laboratory. From the rapidity of its absorbing action, the use of a respirator filled with charcoal has been suggested to protect the mouth and nostrils in an infected atmosphere; trays of powdered wood-charcoal in dissecting-rooms, in the wards of hospitals, and in situations where putrescent animal matter is present, exert a most beneficial influence in sweetening the atmosphere, by absorbing and decomposing the offensive gases. Charcoal is accordingly valuable in filters, not only for decolourising purposes, but likewise for assisting in purifying water for domestic use. It is also successfully used to prevent the escape of noxious vapours at the ventilating openings of sewers, as it allows the free passage of air, but condenses the offensive effluvia in its pores, where they are destroyed by a process of oxidation. Besides its employment in the manufacture of gunpowder it has many applications in the arts. In medicine it is at present chiefly used to destroy fetor; for which purpose it is applied in the form of powder or poultice to gangrenous sores, phagedenic ulcers, &c.; it is also largely employed in tooth-powders, as by its mechanical action it removes incrustations, while by its chemical action it destroys fetor of the breath. In indigestion accompanied by much flatulence it may be given in doses of two or three teaspoonfuls suspended in water, or may be administered in the form of charcoal-biscuits (see BISCUITS). Very finely-divided poplar charcoal is regarded as the best for medicinal uses.

Cheese is a highly nutritious food substance made from milk by elaborate processes which can only be explained in the light of a knowledge of science, chiefly chemistry. Cheeses may be roughly divided into two great classes—*hard* and *soft*. The various English, Scotch, and American cheeses belong to the first class, and are made so that they will generally keep for months, and often continue to improve in quality. Soft cheeses are those which prevail in some parts of the Continent. Many of them require to be consumed immediately after they are manufactured. Their rapid decomposition is associated with a strong and to most people an objectionable smell. Cheese is made from the solids of milk—viz. the casein or chief albuminoid constituent, along with the greater part of the cream or butter-fat, and much of the mineral ash. In fresh milk, which is slightly alkaline, these substances maintain a sort of indescribable union with the watery portion and the milk-sugar—the whole, as is well known, being liquid. The presence of an acid, or of Rennet (q.v.), counteracts the natural affinity of the substances for each other, and the bulk of the solids separate out, forming a soft jelly in the early stages, leaving the bulk of the water containing the sugar as a greenish liquid called Whey (q.v.). The chemical processes involved are as yet only very imperfectly understood.

Milk in decomposing, as it rapidly does in hot and sultry weather, becomes sour in virtue of a natural process of fermentation. Rennet induces another form of fermentation which does not end when the product ceases to be milk, but is carried on in the cheese during the period of its ripening or mellowing. In the early stages of the process of hard cheese-making, the incipient acidity which induces that condition in milk termed 'ripeness,' aids and hastens the action of the rennet. As the work proceeds, and the acidity intensifies, it hardens and contracts the curd, giving it a leathery character, thereby aiding in the expulsion of the whey. One of the most important matters in cheese-making is to watch the development of acidity both in the milk and its first product, the curd. If this is allowed to go too far, the quality of the cheese is seriously injured, and its keeping power is reduced. It cracks through becoming too dry and brittle. The delicate flavouring oils seem to be expelled, and the smell becomes high and the taste 'acid' or 'biting.' The formation of the acid is one of the great helps in cheese-making so long as it is kept in due control. If the acid develops rapidly, as in hot weather, in a temperature which suits the germs producing it, the whole process of manufacture has to be pushed on quickly, whereas in cold weather acidity comes slowly, and the operator must wait until it has come sufficiently. There are several methods adopted in inducing acidity. Acid used to be largely added, as sour whey or buttermilk, but greater uniformity is got by delaying until natural acidity develops. This it does most quickly when the temperature of the material is kept up near to blood-heat. Chilly draughts paralyse the active organisms producing acidity.

Heat is communicated to milk or to its products in the early stages of cheese-making by two methods—either by warming a portion of the milk or whey (though not allowing it to rise much above 100° F.—say a limit of 150° F.—as to boil it would do injury by changing its constitution), and putting it into the main bulk, or by having an outer shell of wood to the tin or iron cheese-tub, with a space between into which steam or hot water can be injected. This arrangement possesses the additional advantage of being clean and of saving labour, although the cost of the apparatus is greater. When the temperature of the evening's milk requires to be reduced to insure its keeping overnight, as in hot weather, cold water can be employed in the same manner as hot water or steam.

It would be misleading to fix definite temperatures or assume definite rules of any kind in speaking of the broad principles and practices of British cheese-making, because there are so many systems which differ materially in important particulars.

A thermometer should be used at all times and in all systems. The old method of testing by the hand hardly now exists, and certainly not among good cheesemakers. The ordinary temperatures at which milk is set or steeped vary with the system adopted and the temperature of the atmosphere—from 80° to 90°, *more or less*, is the nearest indication that it is safe to make. High temperatures are used in making *deep* cheeses, such as Cheddars; low temperatures in making *shallow* cheeses, as the old-fashioned Dunlops. The Gloucester is a well-known variety set at a temperature nearer to 80° than 90° F. By setting at too high a temperature the curd gets hard and tough, though it needs a considerable amount of consistency if it is to retain a symmetrical form in a deep cheese. If worked too cold, the curd is soft and the whey difficult to get out of it, the processes of rennet fermentation and acid fermentation do not go on sufficiently, and their work is imperfect. In all cases the greatest regularity in method should be maintained from day to day.

After heating, the colouring matter (now almost invariably Annatto, q.v.) is put in. This is not considered an adulteration, as it is innocuous. It in no way improves the quality of the cheese, the effect being only upon the colour. All cheeses are not coloured, though the practice is widespread. Rennet is put in about the same time, and after thorough stirring for the purpose of mixing these added ingredients, as well as for keeping down the cream, it is left for 40 or 60 minutes.

Breaking the curd to let out the whey is the next process. Networks of thin wire, or series of thin knives, are passed through it in various directions with great caution, to prevent the curd substance being carried off with the whey, which would give it a white rather than its natural green hue. As the curd hardens it is more quickly worked and finally broken into small particles, so as to allow the whey to escape. The expulsion of the latter is helped on by the contraction of the curd, due to the gradual increase of acidity. Acidity develops naturally if time is allowed, but it is judicious to hasten it by the addition of warm whey during the process of working. Another method of bringing about the necessary amount of acidity is to expose the curd to the air for a time before it is salted. Salt, besides giving a flavour, stops the action of the acidity in cheese after it has done its work of expelling the whey. If allowed to go on, the acidity would destroy the cheese by curtailing the ripening action of rennet. Excess of salt retards the latter process.

After the curd has been broken thoroughly, on being allowed to settle so as to drain off the whey, it adheres together into an india-rubber-like mass; this is cut and broken up into small pieces by its passage through a 'curd-mill.' The finest quality of dairy salt should be used; the crystals being large is an indication of its purity, especially from magnesia salts, which give a bitter taste and otherwise injure all dairy products. The quantity employed is, more or less, about 1 lb. of salt to 56 lb. of curd dry enough to be made up and put into the cheese-press. Its amount should vary with the degree of acidity and the amount of moisture present. In some cases salt is applied wholly or in part dry, or as a brine, to the outside of the cheese after it has been so far pressed. In very rare cases salt is put into the milk before coagulation.

The curd is finally packed into a 'chesset' or

press vat, which has as a temporary lining a cloth of open texture called a 'cheese-cloth.' The vat, which is a strong wooden or tinned-iron vessel with perforations in the sides and bottom to allow of the escape of any little surplus moisture, is placed in a press, and the cheese subjected gradually to a pressure of about one ton. The curd soon assumes the form in which it is to remain as a cheese. For a few days the cloths are taken off regularly and changed; the cheese being turned over each time to make it keep its shape. Ripening is the next process of importance. Deep cheeses are bandaged, and some are covered with cotton cloths (caps) made to fit tightly. They are then placed in the curing or ripening room, which should be dry, well ventilated, and maintained at an even temperature of about 70° F. There the green indigestible and insipid curd changes naturally into the sweet, mellow, nutty, and full-flavoured product cheese, which, if taken in moderation, and especially towards the end of a meal, is an aid to digestion. The ripening process, which is also associated with drying and shrinkage of about 10 per cent. in weight, varies in length from a few weeks to a few months. Acid cheeses are soon ready for market, and spoil if kept for a long time. Sweet cheeses are slow in maturing, and continue to improve even if kept for years. The tendency in cheese-making both in Great Britain and in America has recently been to early maturity, the strong inducement being that of early returns.

The Cheddar system of cheese-making, which first originated in Somersetshire, is, if we embrace Great Britain, Canada, and the United States of America, the most widely practised system of all. The old methods have been much altered in recent times to suit the tendency in the market for early maturity. The following is an account of the system as now practised, with improvements suggested by American and Canadian experience.

The cream is removed from the evening's milk after standing overnight, and is only returned to the full bulk immediately before putting in the rennet; the object is to prevent the cream being made oily by heating to a high temperature. The rennet is added at a temperature ranging from 82° to 88° F., but the milk is heated a few degrees above the point fixed upon for steeping, and left to ripen. The temperature falls to the required point meanwhile. The higher range of temperature is adopted when the milk is sweet and recently drawn from the cow. Low temperatures suit old milk or warm weather. If the cheese is to be marketed within twenty days, enough rennet should be added to induce the initial stages of coagulation within eight to twelve minutes. After this it should be left for twelve to eighteen minutes, then breaking begins with the perpendicular and horizontal cutting knives. It is stirred for about fifteen minutes with a hand-rake, and the temperature afterwards raised to 96°-98° F., or even by some up to 102° F. The whole is allowed to settle and remain nearly an hour to 'cook' the curd. As soon as the latter is elastic enough for the particles to retain their independent shapes on being grasped and squeezed by hand, the bulk of the whey is run off. What remains and the curd, still in small pieces, are removed bodily from the steep-tub or vat, and placed in a flat cooler with an inner movable, sparred, false bottom, to secure drainage. The vessel is lined with a cheese-cloth. On this the curd is exposed to the air and well worked by hand, so as to press out the whey and keep the particles from adhering to one another at too early a stage. After being well worked and exposed it is left to run together, being covered up to preserve heat. It is subsequently cut, piled, and left covered with a cloth for perhaps half an hour. The curd then smells and tastes slightly acid. It is either milled or put through Harris's stamp lever breaker, which cuts it into pieces like fingers. It is subsequently weighed, and should amount to fully 1 lb. to the gallon of milk, and is again exposed to the air to get quit of taints, and to toughen before salting, which should be done when a velvety feeling is noticeable. The salt is added dry at three separate times, and well mixed. The curd is then left to cool down to about 70° F. before being put into the vat. Pressure for about two and a half days is followed by ripening or seasoning. The whole operation of making up the curd may be over in five hours, or may take six or seven hours, according to circumstances. A good Cheddar cheese contains when ripe about 28 per cent. of casein, and nearly 34 per cent. both of butter and of moisture.

Cheshire Cheeses are manufactured in Cheshire, Staffordshire, and Shropshire. In their deep shape and also in many details of their working they resemble Cheddars. Setting is done in a square covered vat, and after making up they are often put into an oven to cook for a night before going to press. In the latter they remain for nearly a week. *Derbyshire Cheeses* are steeped and worked in a manner which closely corresponds to the Cheshire system. The salt, however, is applied externally. *Gloucester Cheeses* are made by a sweet process very much the same as the Derbyshire process. *Double and Single Gloucesters* are identical, with the exception of the thickness and the consequent rate at which they ripen. After a time they are scraped clean and painted with Spanish brown. *Leicester Cheeses* are small and flat, and made by a sweet process. They are at first lightly salted, but salt continues to be added externally. They take a long time to mature.

Stilton Cheeses are made mostly in Leicester. They used to be double cream cheeses, but are now successfully made of the milk as it comes from the cow. The curd is not subjected to pressure like that used in making the previously mentioned forms. While on the shelves ripening it is supported by a bandage, and during that time the characteristic blue mould should form throughout its substance.

Gruyère Cheese, made in the canton of Fribourg, Switzerland, is a whole-milk cheese, as are also the Dutch cheeses of *Gouda* and *Edam*. The fancy cheeses of the Continent, as *Camembert*, *Brie*, *Roquefort*, *Limburg*, *Gorgonzola*, &c., command a high retail price in Britain because of their perishable nature and because their consumption is restricted to a limited and wealthy class. Imitations have been made, but of a spurious and imperfect kind, owing to the impossibility of securing the secrets of their manufacture. The broad facts are known, but not the details. For example, it is quite understood that some soft cheeses are made by mixing old and new curd together. The quality of the natural pastures also affects some, notably the *Parmesan* cheeses from northern Italy.

The American system of cheese-making has been reduced by improved mechanism and association in the form of the factory method to the most economical point. This method of manufacture was a growth by necessity rather than a discovery. A large dairy was divided by the death of the owner, who left three sons. The sons united and manufactured their milk at the old dairy, and in time neighbours joined, and the first factory was established in 1851 under the management of the oldest of the three brothers. In course of time the business increased and became reduced to a most economical basis, while by the employment of skilful operatives the quality of the product was gradually raised. The factories were gradually enlarged until the milk of 1200 cows could be worked up in the largest, and an average factory received the milk of about 400 cows. One Canadian factory makes 216,000 lb. of cheese yearly from the milk of 1300 cows.

The curing occupies about three months, the temperature of the curing-room being kept at 65° F. Gang presses are used, in which a large number of cheeses laid on their sides are pressed at once by turning one screw. A common test by which the ripeness of the curd for pressure is determined is by touching it with a hot iron, and when long strings are drawn from the curd by the iron, the curd is ripe.

Milk is brought to the factory twice daily, and is weighed and run into the vat from the delivery window. The milk is either bought by the factory, or is worked up at a stated charge, or the factory is managed on the co-operative plan in which the net proceeds are divided periodically. Under this factory system the quality of the cheese is uniform and as high as is secured in any well-managed private dairy. About one-fifth of the cheese produced in America is made in private dairies in which the same system prevails.

There are several other kinds of cheese made in both factories and private dairies, as Edam (the round Dutch cheese), a small cylindrical cheese similar to the English Wiltshire, weighing 10 to 14 lb.; a flat cheese called English dairy cheese, similar to the double Gloucester cheese and coloured as highly; a few Stilton cheese; cream cheeses for immediate use; and very good imitations of the European Limburger, Schweizer, Neufchatel, Brie, Gouda, Camembert; and some other fancy makes to supply the French, German, and other immigrant population.

The cows used in the cheese dairies in the United States and Canada are mostly 'grade' shorthorns, or native cows improved by crosses of shorthorn, Devon, Ayrshire, and Dutch breeds. Jersey and Guernsey cows, and the best of the higher bred animals, are used for the highest class of cheese of the fancy kinds. The profitable exploitation of the dairy in America has raised the value of lands suitable for grazing cows to an average value of nearly \$100 (£20) per acre for the fee simple, which is twice as much as that of grain farms. The cheese-dairy business prevails mostly in the states of New York, Pennsylvania, Ohio, Iowa, and Wisconsin, and in the province of Ontario, Canada. The cows are chiefly fed upon pasturage aided in the latter part of the summer by soiling crops, of which maize is almost universally chiefly depended upon. The cheese-making season begins in April and continues until November. See X. A. Willard's *Practical Dairy Husbandry* (1875), L. B. Arnold's *American Dairying* (1877), and Henry Stewart's *American Dairyman's Manual*.

CHEESE-PRESS.—The most common form is the *lever* press. A powerful steel coil or spring is sometimes substituted for the lever. In large factories the *gang* press is employed to press a large number of cheeses at one time by means of a powerful horizontal screw. The old method was by placing a heavy stone (hence the name stoning cheese) on the lid of the chessart, or by hanging it by a ring fixed to its upper side from the end of a wooden beam which acted as a lever and passed over the lid of the cheese-press vat.

Chemical Affinity is the name given to the tendency to combine with one another which is exhibited by many substances; or to the force by which the substances constituting a compound are held together. The tendency of any given element to unite with a number of other elements varies greatly. Chlorine, for instance, unites with great readiness with most metals and with many non-metallic elements, much heat being produced during the union; but it has little or no affinity for, or tendency to combine with, oxygen, so that compounds of chlorine with oxygen can only be obtained by roundabout methods, and are very liable to sudden and explosive decomposition into chlorine and oxygen. Where the affinity of elements for each other is great, the compounds produced by their union are decomposed with difficulty, and where the affinity is feeble, decomposition is easily affected. See also CHEMISTRY.

Chemistry. Although chemistry has only taken its place as an exact science based upon accurate experimental investigation within a comparatively recent period, yet its origin dates back to the earliest times of philosophical study. It will be convenient to give in the first place a short sketch of the history of chemistry, and then to state some of the principles of the science, illustrating these from the simplest facts. When possible, such illustrations will be chosen as are likely to be not altogether unfamiliar to non-scientific readers.

Historical Sketch.—The word *chemistry* has come to us from the Greek through the Arabic, as shown in our article ALCHEMY. With regard to the chemistry of the ancients, we know that the ancient Egyptians, Phœnicians, Greeks, and Romans were acquainted with a very considerable number of useful substances, and that their processes for preparing some of these did not differ in any essential particular from those now in use. It does not appear, however, that they have left any chemical records behind them, or that they knew anything of the science of chemistry. Several metals were known to, and employed by, these ancient peoples, who were acquainted with processes for reducing them from their ores. Amongst these metals were gold, silver, mercury, copper, tin, lead, and iron; whilst they also knew and worked with brass, although they were not aware that it was an alloy of copper and zinc. Various alloys were employed for bronzes for statues, and these usually contained copper, lead, and tin. The processes for manufacturing soap, starch, glass, leather, various mineral and vegetable pigments, stoneware, and other useful substances, were all known and carried on in very early times; and wine and beer appear likewise to have been prepared and used as beverages long before the process of distillation, which was unknown to the ancients, had been introduced. Vinegar, sulphur, and carbonate of soda were also known.

We find the application in medicine of many chemical products at a comparatively early period, and the Arabians appear to have been the first who tried to prepare new medicines by chemical methods. Geber, who lived in the 8th century A.D., is the most noted of the Arabian chemists, and he has left some writings which show us what was the state of chemistry at that early date. Geber knew, for instance, how to make and distil vinegar and nitric acid, and even sulphuric acid was made and used as a solvent by him. He knew, amongst other substances, white arsenic, borax, common salt, alum, sal-ammoniac (ammonium chloride), copperas (ferrous sulphate), nitre (potassium nitrate), and corrosive sublimate (mercuric chloride), and was acquainted with a number of their properties. He used almost all the kinds of apparatus that were commonly in use down till the 18th century, and understood the processes of distillation, filtration, sublimation, and crystallisation. In one of his works he describes the construction of furnaces for chemical purposes.

From the 8th till the 17th century but little real progress was made in chemistry as a science. The new knowledge that was gained during this period was mainly due to the assiduity of the alchemists, who, in their vain search for the philosopher's stone, necessarily made useful discoveries from time to time. Many of the alchemists so called were mere tricksters who deceived their dupes by more or less clumsy experiments, which appeared to demonstrate the production of gold from baser metal. Others, however, were really earnest and untiring in their labours, and held the fullest belief in the prospects of the ultimate success of some fortunate worker. The new substances obtained by the alchemists were frequently used in medicine, and it is to these infatuated workers, therefore, that we owe our first knowledge of many potent medicines. The writings of many of the alchemists are preserved, but numbers of them are entirely worthless from a scientific point of view, as the descriptions of processes are mixed up with so much of mystery and extravagance that they present a wholly unintelligible jargon. For more detail, however, regarding this remarkable period in the history of chemistry, see the article ALCHEMY.

As Geber has been called the patriarch of chemistry, so Robert Boyle (1627-91) has been called the father of modern chemistry, since it was Boyle who first tried to free chemistry from the trammels of alchemy and to place it upon a true scientific basis. Boyle in his *Sceptical Chemist* tried to discredit the salt, sulphur, and mercury of the alchemists (as well as the Aristotelian earth, air, fire, and water) as elements or ultimate constituents of substances, and he gave a scientific definition of an element. Boyle was an experimental investigator of considerable skill, and to him we owe the introduction of the air-pump and the thermometer into this country. His experiments upon the physical properties of gases led to the formulation of the law concerning the relation of the volume of a gas to the pressure, which is commonly known as Boyle's Law.

Theory in modern chemistry begins with Becher (1635-82) and Stahl (1660-1734). The latter adopted, with some modifications, a theory propounded by the former concerning elements and compounds, and formulated the phlogiston theory of combustion. The views of Becher and Stahl regarding elements were not so enlightened as those of Boyle, and must be considered as retrograde. Stahl's phlogiston theory (1697) was at once adopted almost universally by chemists, and for fifty years it was held to give the full explanation of the phenomena of combustion. According to this theory phlogiston was a constituent of all combustible substances. When a substance burned, the phlogiston made its escape, and the product of combustion was regarded as the other substance with which the phlogiston had been previously united. When a metal such as lead was heated in the air, it lost its phlogiston, and the oxide formed was looked upon as the other constituent of lead besides phlogiston. The process of reduction of lead from its oxide by means of charcoal was the transfer of phlogiston from the charcoal to the lead. It did not present itself to the adherents of the theory as an absurdity that a metal, in losing its phlogiston on oxidation, gained weight, although some of them at least were aware of the fact. The idea of gain of matter being a necessary accompaniment of gain of weight is so familiar to us that we can scarcely realise that it was not always so regarded. To this may fairly be attributed the persistence with which the phlogiston theory held its ground for so long a period.

The Dutch chemist Boerhaave (1668-1738), who did not accept Stahl's theory, published in 1732 his system of chemistry, which was a compilation of practically all that was known up till that date, collected with great labour from a large variety of alchemical and other writings.

The interval between the introduction of the phlogiston theory and its overthrow by Lavoisier in 1772-85 was one of great advance in chemical knowledge, and a number of very eminent chemists preceded and were contemporaries of Lavoisier.

In Germany, Marggraf (1709-82) studied the properties of the almost unknown alumina and magnesia, and made considerable advances in the qualitative analysis of substances in solution.

Amongst British chemists of note may be mentioned Hales (1677-1761), who was amongst the first to experiment on gases; Black (1728-99), who in 1756 published his research on *Magnesia Alba*, showing the nature of fixed air or carbonic acid gas, and of the difference between caustic and mild (or carbonated) alkalies; Priestley (1733-1804), who, in addition to his discovery of oxygen in 1774, investigated nitric oxide, nitrous oxide, sulphurous acid, carbonic oxide, hydrochloric acid, and ammonia gases, being specially attracted to the study of gaseous substances and their properties; and Cavendish (1731-1810), who investigated the nature and properties of hydrogen, analysed atmospheric air, and discovered the compound nature and composition of water and of nitric acid.

Lavoisier (1743-94) was one of the ablest chemists of his time, and his labours include a vast variety of subjects. His attack upon, and eventual demolition of the phlogiston theory, and his experiments in connection with his new theory of combustion, occupied him for a considerable number of years. He taught that combustion was the union of the combustible substance with atmospheric oxygen; he was the first to introduce system into chemistry and chemical research; he determined the constituents of a large number of substances, including sulphuric, phosphoric, and carbonic acids, numerous metallic oxides, and many animal and vegetable substances; and he, along with Berthollet, Fourcroy, and Morveau (1737-1816), introduced a new and consistent system of chemical nomenclature. Two contemporary Swedish chemists, Bergman (1735-84) and Scheele (1742-86), must be mentioned before leaving the phlogiston age. Bergman investigated, amongst other things, carbonic acid gas, studied the phenomena of affinity, and made advances in the processes and reagents used in qualitative analysis. Scheele was one of the most laborious chemists of his time. He discovered citric, malic, tartaric, oxalic, lactic, hydrocyanic, arsenic and other acids, and chlorine, besides investigating the nature of a large number of other bodies and independently discovering oxygen.

It was towards the end of the 18th century that the value of quantitative analysis of substances began to be generally recognised. The question as to whether the quantitative composition of a given substance was always the same gave rise to a discussion which lasted for several years, and was at length decided in favour of constant composition.

The researches of Richter (1762-1807) on the quantities of various acids neutralised by a given quantity of a base, and of various bases neutralised by a given quantity of an acid, led him to the general conclusion that the quantities of two acids, a and a', which form neutral salts, $a\ b$, and $a'\ b'$, with the quantities of two bases, b and b', are just the quantities required to form two other neutral salts, $a\ b'$ and $a'\ b$. This fundamental discovery was erroneously attributed to Wenzel by Berzelius in 1819, and the error has been carefully perpetuated in a considerable number of text-books since that time (Kopp, *Entwickelung der Chemie in der neueren Zeit*, p. 251).

Berthollet (1748-1822), who was one of the most active opponents of the theory of the constant composition of chemical substances, contributed valuable researches into the laws of chemical affinity, and applied chlorine to processes of bleaching. The processes of chemical analysis were improved, and large numbers of analyses, especially of minerals, were carried out by Klaproth (1743-1817), Vauquelin (1763-1829), Fourcroy (1755-1809), and others; and many quantitative observations of all kinds were made about the end of the 18th century, all preparing the way for Dalton's statement of the Atomic Theory (q.v.) in 1803-4.

The progress of chemistry during the present century has been immense, and it is not possible to do much more than mention the names of some of the most prominent workers. A stimulus was given to research by the publication of Dalton's atomic theory; and the labours of Gay-Lussac (1778-1850), who experimented with gases, of Dulong (1785-1838), and Petit (1791-1820), who pointed out the relation between specific heats and atomic weights of elements, and of others, supported and amplified Dalton's views.

Wollaston (1767-1829) discovered palladium in 1803, and rhodium in 1804. The first alkaloid (morphine) was obtained pure by Sertürner in 1816, and this led to the discovery of a number of others in a short time.

The decomposition by electricity of the bases potash and soda by Davy (1778-1829) in 1807, and the separation from these of the metals potassium and sodium, threw an entirely new light on the nature of these substances. The metals were more fully investigated by Gay-Lussac and Thénard (1777-1857). Davy is noted also as the inventor of the miners' safety-lamp, and for experiments on the respiration of nitrous oxide and other gases.

Amongst the foremost chemists of the earlier part of the 19th century was the Swede Berzelius (1779-1848), whose careful and exact analyses of mineral substances contributed a good deal to the confirmation of the law of constant proportions and to the fixing of the atomic weights (see ATOMIC THEORY) of the elements. Berzelius was very conservative with regard to new theories, which he declined to accept without putting them to the strictest experimental tests. He formulated the electro-chemical theory of the constitution of salts, introduced great improvements into the methods of quantitative analysis, increased the value of the blowpipe as an aid in mineral analysis, discovered many new substances, and further examined and elucidated points concerning many already known, both inorganic and organic.

The artificial production of urea in 1828 by Wöhler (1800-82) marks the beginning of a new era in the branch of organic chemistry, and enormous strides have been made in this department since that time by Dumas (1800-84), Liebig (1803-73), Laurent (1807-53), Gerhardt (1816-56), Wurtz (1817-84), Kolbe (1818-84), Baeyer, Cannizzaro, Frankland, Hofmann, Kekulé, Williamson, and many others. Advances in general inorganic chemistry and analysis have been made by Leopold Gmelin (1788-1853), H. Rose (1795-1864), Sainte-Claire Deville (1818-81), and Bunsen; whilst in connection with advances in chemical physics may be mentioned Faraday (1791-1867), Mitscherlich (1794-1863), Graham (1805-69), Regnault (1810-78), Andrews (1813-85), and Berthelot. These lists do not include all of even the most prominent names that might be mentioned in connection with each department.

The most striking feature of modern chemistry is the extraordinary development of organic chemistry, the account of one branch of it—the chemistry of the coal-tar products—constituting of itself quite a literature which receives additions every day.

Amongst the most recent triumphs of chemical research may be mentioned the artificial production of indigo and grape-sugar, and the isolation, in sufficient quantities to study its properties, of the hitherto all but unknown element fluorine.

Of the greatest possible interest from a theoretical point of view is the fact that since 1870 three new elements have been discovered—gallium, scandium, and germanium—the existence of all of which had been predicted, and the properties of which had to a certain extent been described beforehand by Mendeléeff. (See periodic law in article ATOMIC THEORY.)

Of late much attention has been given to measurements of the quantity of heat produced in various chemical changes, notably by Berthelot and Thomsen.

Elementary Principles of Chemistry.—The science of chemistry deals with a certain class of changes which matter undergoes when subjected to particular conditions. Similar treatment may produce very different effects upon different substances, as, for instance, the effect of strong heat upon a piece of quartz, a piece of limestone, and a piece of sugar. The quartz does not suffer any *permanent* change, that is, it has the same properties after it is cold again as it had before the action of heat. The limestone, although not necessarily much altered in appearance, has its properties entirely changed, and what remains is a new kind of matter—quicklime. The sugar melts, darkens, and chars, and becomes quite manifestly changed into more than one new kind of matter, for gaseous products, having the smell characteristic of 'burnt sugar,' go off, whilst a black coaly mass remains.

The first of the above changes is merely a *physical* change, from cold to hot; the other two are *chemical* changes, which result in the production of new kinds of matter having properties entirely different from those of the kinds of matter from which they were obtained. The existence of chemistry depends upon the existence of different kinds of matter, and it is with such different kinds of matter and the change from one kind to another that chemistry has to do.

When the properties of matter are studied, it is found that for chemical purposes all kinds of matter may be divided into two great classes, which are called respectively *elements* and *compounds*. The name element is applied to any kind of matter that has not been proved to be composed of more than one simpler kind of matter. This conception of an elementary substance we owe to Boyle, and it will be noted that some of those substances which are now looked upon as elements (see article ATOMIC THEORY for a list of the 68 known elements) may hereafter be proved to be *compounds*, or kinds of matter composed of more than one simpler kind, just as some substances which were at one time rightly classed as elements (according to Boyle's definition) are now known to be compounds of two or more elements.

The compound nature of a specimen of matter may be proved in one or other (or both) of two ways. One of these methods is called *Synthesis* (q.v.), and consists in building up the compound from the component simpler kinds; the other is called *Analysis* (q.v.), and consists in separating more than one simpler kind from the compound kind.

The distinction between chemical compounds and mere mechanical mixtures is a fundamental one, and must be fully understood. The substance gunpowder, for instance, is an intimate mixture of finely powdered sulphur, charcoal, and saltpetre (potassium nitrate), certain precautions being observed during the mixing in order to avoid explosion. These substances are not combined together chemically in gunpowder, but are only mixed, a fact as to which we can easily satisfy ourselves in various ways. We may examine the gunpowder under the microscope and identify the separate particles of the ingredients; or, by the use of appropriate solvents, we may dissolve out first the saltpetre and then the sulphur, and thus recover all three ingredients separately. The explosion of gunpowder when heated to a sufficiently high temperature is due to the occurrence of a series of changes of the kind we call chemical, for these changes result in the production of new kinds of matter, gaseous and solid, which possess properties in no way resembling those of sulphur, charcoal, or saltpetre, and from which these substances cannot now be dissolved out.

A mixture possesses to a greater or less extent the properties of its respective ingredients; a compound, on the other hand, has not as a rule any properties resembling those of its constituents. A piece of magnesium wire heated in the air to a sufficiently high temperature takes fire and burns. This is a chemical change in which the metal magnesium combines with the oxygen of the air to form a white, brittle, solid compound called magnesia or magnesium oxide. This magnesia does not in the least resemble either magnesium or oxygen in its properties, and the most powerful microscope fails to reveal particles of either of these substances to our vision.

The Atomic Theory (q.v.) is based upon the assumption that matter of every kind is made up of extremely minute indivisible particles called *atoms*. The atoms which exist in a substance may be all of the same kind, as in elements, or of different kinds, as in compounds. Chemists believe that the element hydrogen consists of *molecules* or aggregates of atoms—each molecule consisting of two atoms; further, that the compound substance water consists of molecules, each composed of two atoms of hydrogen and an atom of oxygen united to each other by that force which is called *Chemical Affinity* (q.v.); and that similarly every other compound substance is composed of molecules, each molecule consisting of two or more different kinds of atoms united by chemical affinity. The weight of a new compound formed by the union of two or more substances is in every case equal to the sum of the weights of its constituents. In chemical actions it is only the *kind* of matter which is changed, whilst, as in every physical change, the *quantity* of matter concerned remains constant and unalterable.

It has already been seen that one of the characteristics of the chemical combination of two substances is that the properties of both disappear and are not observable in the compound. Another and a most important characteristic is the evolution of heat, which is a very frequent although not an invariable accompaniment of chemical action. The best examples of this may be seen in the ordinary phenomena of Combustion (q.v.). All combustion, whether it be of magnesium wire, coal, phosphorus, paraffin oil, or a candle, is nothing more than a chemical action accompanied by the evolution of heat and light, oxygen gas of the atmosphere being almost invariably one of the substances taking part in such action.

The conditions under which substances act chemically upon each other are very various for different substances. In the first place, certain substances cannot be got to act upon each other at all. Such substances may have little affinity for each other, as chlorine and oxygen, or no affinity, as fluorine and oxygen. Other substances, again, only act upon each other with difficulty. The main conditions upon which action of one substance upon another depends are the state of physical aggregation and the temperature. Certain chemical actions take place at ordinary temperatures, as, for instance, the combination of chlorine with metallic antimony or copper, or the spontaneous ignition of one of the compounds of phosphorus and hydrogen when brought into contact with oxygen. Other actions only take place when the temperature of the substances which are to take part in them has been sufficiently raised. Thus magnesium requires to be strongly heated in air before it takes fire; once the action is started, however, the heat given out by the combination of one part of the magnesium is sufficient to raise another part to the temperature necessary for combustion to go on, and so the change is propagated. Coal-gas only burns in air when it is raised to a bright-red heat. A jet of coal-gas escaping into the air may be easily ignited by applying a brightly red-hot poker, but when the poker cools to dull redness it will no longer ignite the jet. A bar of metallic iron does not undergo any chemical change on exposure to dry air at ordinary temperature, but if iron in the state of very fine powder (a form in which it can easily be obtained by appropriate methods) be thrown into the air, combination at once takes place with the evolution of heat and light. When a piece of iron (say a moderately fine iron wire) is heated to redness in air, combination with the oxygen of the air takes place with the formation of a scale composed of a black oxide of iron, but the quantity of heat given out during the combination is not sufficient to propagate the combustion from particle to particle of the iron after removal of the source of heat. If, however, iron wire be raised to a red heat in an atmosphere of oxygen, it takes fire and burns with great brilliancy. The difference noticed here is due to the presence in the one case, and the absence in the other, of the diluting nitrogen which forms nearly four-fifths of the air by volume.

There are certain chemical actions which in taking place are accompanied, not with evolution, but with absorption of heat. In such cases heat has to be supplied throughout the action, and not merely to start it. This is frequently noticed in the combination of substances which have feeble affinity for each other, and the compounds produced are less stable, or more readily break up into their constituents, than those which are produced with the evolution of heat. In general terms it may be stated that the quantity of heat given out in the formation of a compound is a measure of the stability of the compound. When a given weight of magnesium unites with oxygen to form magnesia, a quite definite and measurable quantity of heat is given out. In order to separate the magnesium from the oxygen again, exactly the same quantity of heat must be supplied. In the case of those substances in the formation of which heat is absorbed, we find, as we should expect, that heat is given out during their decomposition, and that its quantity is exactly that which was absorbed during their formation.

Chemical Notation.—For the purpose of shortly expressing the composition of chemical substances, and for representing chemical changes, chemists employ a system of notation which is in extremely common use. In the table of Atomic Weights (see ATOMIC THEORY) it will be noticed that after the name of each element is placed its *symbol*, which usually consists of the first, or of the first and another letter of the Latin name of the element. Each symbol distinctly indicates the element which it is intended to represent, but it must always be borne in mind that the symbol for an element is not merely a contracted form of its name, but that it stands for a definite quantity of that element, this quantity being the atomic weight expressed in terms of the unit of weight employed.

The unit of weight almost universally employed by chemists and scientific men in general is the gramme (see METRIC SYSTEM), and that unit will be adopted for illustrations throughout this article. With the gramme as unit, H stands for 1 gramme of hydrogen, Cl for 35·4 grammes of chlorine, O for 16 grammes of oxygen, Mg for 24 grammes of magnesium, and so on. In order to represent the composition of a compound, the symbols of the various elements which occur in the compound are written side by side, and this collection of symbols is called a *formula*. Thus, MgO represents 40 (= 24 + 16) grammes of magnesium oxide, and HCl is 36·4 (= 1 + 35·4) grammes of hydrogen chloride. When a compound contains more than one atom of the same element the symbol for that element is not repeated, but the number of atoms is indicated by a subscribed numeral. Thus the formula for water is written H_2O, which indicates that the molecule of water contains two atoms of hydrogen and one of oxygen; and the formula for sulphuric acid is written H_2SO_4, which indicates that the molecule of sulphuric acid contains two atoms of hydrogen, one of sulphur, and four of oxygen (besides the quantitative signification of these formulæ already mentioned). A number subscribed to a portion of a formula inclosed in brackets multiplies the portion so inclosed. Thus the formula $Ba(NO_3)_2$ represents one atom of barium united to twice the quantity of the group NO_3, which is represented as united to one atom of potassium in the formula KNO_3. A number prefixed to a formula multiplies the whole of the formula that follows. Thus $2H_2O$ represents twice the quantity of water represented by H_2O.

Chemical symbols and formulæ are used to represent shortly chemical changes. A simple illustration of the method of using them may be given to represent the case of the burning of magnesium. The symbols for the magnesium and the oxygen entering into combination (connected by the sign +) are written on one side of what is called a chemical equation, whilst the product is written on the other side, thus:

$$2Mg + O_2 = 2MgO.$$

The formula for free (or uncombined) oxygen is written O_2, because a molecule of oxygen is believed to consist of two atoms (see ATOMIC THEORY). In order to represent the element magnesium, the simplest possible formula (Mg) is employed because there is no evidence for writing a more complicated one. 2Mg simply represents twice as much magnesium as Mg does.

The above equation when fully interpreted gives a great deal of information about the change which it is intended to represent. It shows that magnesium and oxygen unite with each other (under conditions which are not expressed) to form an oxide of magnesium, and that these elements are united in the compound in the proportions by weight of 24 of magnesium to 16 of oxygen; and, further, it enables us, by applying a simple and easily remembered rule, to calculate the *volume* of oxygen taking part in the action as well as its weight. This rule for ascertaining the volume may be conveniently stated here. From certain theoretical considerations, as well as for convenience in calculations concerning the volumes of gases, chemists write the formulæ of gaseous substances in such a way that the quantity of a gas represented by its formula, in terms of any unit of weight, shall occupy, under similar conditions of temperature and pressure, the same volume as two units weight of hydrogen. Thus, the unit being the gramme, H_2 represents 2 grammes of hydrogen, and 2 grammes of hydrogen at *standard* temperature (0° C.) and pressure (760 millimetres of mercury) occupy a volume of

22·33 litres (see METRIC SYSTEM). Similarly, the quantities in grammes of oxygen, carbonic anhydride, and nitrous oxide, represented by their respective formulæ, O_2 (16 × 2 = 32 grammes), CO_2 (12 + 32 = 44 grammes), and N_2O (28 + 16 = 44 grammes), each occupy, when measured at 0° C. and 760 mm. pressure, 22·33 litres. This rule holds for other gases, and also, with a certain qualification, for the vapours of volatile liquids. In the case of the latter, of course, conditions of temperature and pressure must be chosen such that the substance is in the state of vapour; and the quantity in grammes which, as a vapour, occupies the same volume as 2 grammes of hydrogen under the same conditions, is the quantity which the formula is chosen to represent. Thus, the formula H_2O informs us that 18 (= 2 + 16) grammes of water occupy, in the form of steam, the same volume as 2 grammes of hydrogen when both are measured at the same temperature and pressure. It must, of course, be understood that the formula for a substance is chosen so as to represent the observed facts. The formula of a volatile liquid is deduced from the determination of the *vapour density* of the liquid; this determination is made by ascertaining the weight of that quantity of the liquid which, when converted into the state of vapour, occupies the same volume as a given weight of hydrogen, both being measured at the same temperature and pressure.

Returning to the equation already given, it will be seen that from it we learn that 48 (= 2 × 24) grammes of magnesium unite to form magnesium oxide with a quantity of oxygen (32 grammes) which at 0° C. and 760 mm. occupies 22·33 litres. What volume this quantity of oxygen would occupy under other conditions of temperature and pressure can be calculated from formulæ deduced from the laws of Charles (relation of the volume of a gas to the temperature) and Boyle (relation of the volume of a gas to the pressure). See further in article GASES.

As there are certain conditions under which chemical combination takes place, so there are definite laws which regulate combination. The first of these has been called the *law of constant proportions*, and it states that any chemical compound always contains the same constituents and in the same proportions. Thus magnesium oxide, MgO, always consists of magnesium and oxygen in the proportions by weight of 24 to 16—one atom of magnesium weighing 24, being combined with one atom of oxygen weighing 16. No compound of magnesium and oxygen containing these elements in any other proportion has ever been obtained. If in preparing magnesium oxide quantities of magnesium and oxygen were employed differing from this proportion, then some either of the magnesium or of the oxygen would remain over after the action, according as the former or the latter had been employed in excess of the right quantity.

Intimately connected with the foregoing law is the *law of multiple proportions*. Whilst certain elements combine with each other in only one proportion by weight, others combine in two, and sometimes more than two different proportions. The law of multiple proportions states that when elements combine in two or more proportions these various proportions can be expressed by simple multiples of the atomic weights of the elements concerned. Thus carbon and oxygen unite with each other to form two different compounds; 12 parts by weight of carbon unite with 16 parts by weight of oxygen to form carbonic oxide, CO; 12 parts by weight of carbon unite with 32 parts by weight of oxygen to form carbonic anhydride, CO_2. Here the relation is of the simplest kind, for the one compound contains exactly twice as much oxygen for the same quantity of carbon as the other. Again, iron and oxygen unite with each other to form three different compounds: 56 parts by weight of iron unite with 16 parts by weight of oxygen to form ferrous oxide, FeO; 112 parts by weight of iron unite with 48 parts by weight of oxygen to form ferric oxide, Fe_2O_3; 168 parts by weight of iron unite with 64 parts by weight of oxygen to form ferroso-ferric oxide, Fe_3O_4. This case is not quite so simple as that of the oxides of carbon, for here it is necessary to employ multiples of the atomic weights of both elements concerned in order to see the simplicity of the quantitative relations existing amongst these oxides of iron. The law of multiple proportions is, however, fully illustrated by both series of oxides.

It may be useful to call attention here to the simple explanation furnished by the Atomic Theory (q.v.) for the occurrence of compounds illustrating this law of multiple proportions. There is no compound intermediate in composition between carbonic oxide and carbonic anhydride. The atomic theory explains this very simply. Under one set of conditions we can obtain a compound of one atom of carbon with one atom of oxygen, whilst under other conditions we obtain a compound of one atom of carbon with two atoms of oxygen, or exactly twice as much. This is why we find such marked intervals in composition between two or more compounds of the same elements. The molecule of one compound cannot differ from that of the other by less than an atom, and the addition of an atom to a molecule necessarily forms a new molecule differing in weight from the old one by the weight of the added atom.

The last law of combination has been called the *law of volumes*. It states that when gases combine to form new compounds, the volumes taking part in the action bear a very simple relation to each other and to the volume of the product if gaseous when all the volumes are measured at the same temperature and pressure. Thus, one volume of hydrogen combines with one volume of chlorine to form two volumes of hydrochloric acid gas; two volumes of hydrogen combine with one volume of oxygen to form two volumes of water vapour; two volumes of carbonic oxide combine with one volume of oxygen to form two volumes of carbonic anhydride, and so forth. The very simple relations of the volumes concerned in these examples are sufficiently manifest, and much greater complexity is not frequently met with.

Chemists divide the elements into two great classes, the typical members of which are very different in their physical and chemical characters. These are *metals* and *non-metals*, and as representative of each class may be mentioned copper and sulphur. The more prominent physical characteristics of metals are the metallic lustre, malleability, ductility, and the property of conducting heat and electricity, all of which are possessed to a more or less marked degree; whilst non-metallic elements as a rule possess these properties to a very limited extent, if at all. Differences in chemical behaviour are also very striking in typical representatives of each group. It must be borne in mind, however, that all the members of each group are not typical, but that there is a gradual transition from one group to the other, and certain of the transition elements possess some of the properties of both groups, as in the cases, for instance, of arsenic and antimony.

With the exception of bromine and fluorine, all the elements enter into combination directly or indirectly with oxygen to form oxides. The oxides produced from metallic elements are quite different in chemical character from those produced from non-metallic elements. We shall look first at the oxides of the metals. Every metal forms one or more oxides, and at least one oxide of every metal is a *basic oxide*—i.e. an oxide which has the properties of a Base (q.v.). A distinction is made between what are called *anhydrous bases* and *hydrated bases* or *hydroxides*. The oxide of lead, PbO, is an anhydrous base (or basic oxide), whilst the compound obtained by the action of water upon calcium oxide, CaO (a basic oxide, and the only compound of calcium and oxygen known), is called a hydrated base (or hydroxide). The formation of the latter is represented by the equation

$$CaO + H_2O = Ca(HO)_2.$$

The oxides produced from non-metallic elements are very frequently *acid* oxides—i.e. oxides which unite with water to form the class of bodies called *Acids* (q.v.). The oxides themselves are often called *acid anhydrides*, whilst the compounds produced by the action of water upon them are called acids, or *hydrogen salts*. When phosphorus burns in air, phosphoric anhydride, P_2O_5, is obtained. This is a white solid substance which unites with water with the evolution of much heat to form a solution of metaphosphoric acid, or hydrogen metaphosphate:

$$P_2O_5 + H_2O = 2HPO_3.$$

There are a few acids known which do not contain oxygen, and are not obtainable by the combination of an oxide with water. Examples are hydrochloric acid, HCl, hydrobromic acid, HBr, and hydrocyanic acid, HCN. These are also called hydrogen chloride, bromide, and cyanide respectively.

The two classes of substances, bases and acids, are nearly related to the very large class of *salts*. A salt is a compound which can be obtained, amongst other ways, by the action of an acid upon a base, water being almost invariably eliminated at the same time; and just as we saw that the properties of two elements are totally different from those of the compound formed by their combination, so we find that in the formation of a salt the properties of both acid and base to a great extent or altogether become neutralised and disappear.

If to a solution in water of potassium hydroxide, KHO (which is a powerful base), we add a sufficient quantity of nitric acid, HNO_3, that is until the liquid on thoroughly mixing does not possess either the acid or the alkaline reaction, we obtain a solution in water of potassium nitrate (saltpetre), and nothing else—the water eliminated in the action simply mixing with that which is already present:

$$KHO + HNO_3 = KNO_3 + H_2O.$$

Acids have already been mentioned as hydrogen salts. The above equation shows how hydrogen nitrate is exactly comparable with potassium nitrate—an atom of potassium taking the place of an atom of hydrogen—and a characteristic of all hydrogen salts, or acids, is that they contain hydrogen, which is capable of removal and of having its place thus taken by an equivalent quantity of another metal. In the example above mentioned every 1 part by weight of hydrogen has its place taken by 39 parts by weight of potassium. These quantities of hydrogen and of potassium are equivalent, both being capable of uniting with the group NO_3. This group is an example of what is called a *compound radical*—i.e. a group of elements which is capable of going as a whole through a series of changes. Acids which contain in their molecule one atom of hydrogen replaceable by another metal are called *monobasic* acids. Nitric acid is thus a monobasic acid, whilst sulphuric acid, H_2SO_4, is *dibasic*, orthophosphoric acid, H_3PO_4, is *tribasic*, and so on.

Bases, likewise, are sometimes spoken of as *monacid*, *diacid*, *triacid*, and so on, according as one molecule of the base requires one, two, three, &c. molecules of a monobasic acid (as nitric acid) to form what is called a *normal* salt, that is, a salt in which all the replaceable hydrogen has been replaced by another metal. Thus potassium hydroxide, KHO, is a monacid base; calcium hydroxide, or slaked lime, $Ca(HO)_2$, is diacid; bismuth hydroxide, $Bi(HO)_3$, is triacid, and so on. Equations may make this clearer (see the equation above for a monacid base):

$$Ca(HO)_2 + 2HNO_3 = Ca(NO_3)_2 + 2H_2O;$$
$$Bi(HO)_3 + 3HNO_3 = Bi(NO_3)_3 + 3H_2O.$$

Salts are formed in many cases by the replacement of only a *part* of the replaceable hydrogen of a hydrogen salt by another metal. Such are called *acid salts*, and $KHSO_4$ is an example. This salt, $KHSO_4$, may be looked upon as intermediate between the acid, H_2SO_4, and the normal salt, K_2SO_4.

Many salts are known which may be looked upon as bases which have their basic character only partially neutralised by an acid. Such salts are called *basic salts*, and as examples may be mentioned $BiONO_3$ and $Pb(OH)NO_3$. The former is intermediate between the normal nitrate, $Bi(NO_3)_3$, and the oxide, Bi_2O_3, the latter between the normal nitrate, $Pb(NO_3)_2$, and the hydrate, $Pb(OH)_2$. Such basic salts are often produced by the action of water upon the normal salts, as, for instance, in the case of the basic bismuth nitrate:

$$Bi(NO_3)_3 + H_2O = 2HNO_3 + BiONO_3.$$

Salts are looked upon as being composed of metal and *salt radical*, the latter name being given to all of the salt that is not metal. Thus SO_4 is the salt radical of the sulphates, NO_3 the salt radical of the nitrates, &c. This way of looking at salts arises from the phenomena observed when salts are decomposed by Electrolysis (q.v.), metal and salt radical being the primary products of decomposition.

Chemical Nomenclature.—Chemists endeavour to make the nomenclature of compound substances as systematic as possible, and a certain amount of system has even been introduced into the nomenclature of the elements themselves. The oxides of the metals are named after the metal which they contain, as magnesium oxide, MgO; aluminium oxide, Al_2O_3; and the series of salts derivable from these oxides are similarly named after the metal. Thus $MgCl_2$ is magnesium chloride, and $Al_2(SO_4)_3$ is aluminium sulphate. When a metal forms more than one basic oxide, adjectival terminations are employed to distinguish these; thus the two basic oxides of iron are named ferrous and ferric oxides (FeO and Fe_2O_3) respectively, and correspondingly there are ferrous and ferric salts. $FeSO_4$ is ferrous sulphate; Fe_2Cl_6 is ferric chloride. Acid salts and in general salts which contain more than one metal are named after the metals which they contain, the compound radical NH_4 (ammonium; see AMMONIA) being regarded as a metal for purposes of nomenclature. Thus, $KHSO_4$ is potassium hydrogen sulphate, whilst $HNaNH_4PO_4$ is hydrogen sodium ammonium orthophosphate.

The nomenclature of non-basic metallic oxides has been rendered systematic by the use of names descriptive of the number of atoms of metal and of oxygen contained in the oxide, as, for instance, trimanganic tetroxide for Mn_3O_4. A considerable number of non-basic oxides, as BaO_2, PbO_2, MnO_2, &c., are somewhat less systematically called *peroxides*.

The acid anhydrides, which, as has already been stated, are oxygen compounds or oxides of the non-metallic elements, are named after the elements of which they are oxides. As there are frequently two or more such acid anhydrides derived from one element, different terminations and, where necessary, other devices of nomenclature are employed to distinguish amongst these. Thus there are two acid anhydrides derived from sulphur—sulphurous anhydride, SO_2, and sulphuric anhydride, SO_3. The latter unites with water to form sulphuric acid, H_2SO_4, and it is believed by some chemists that the solution in water of sulphurous anhydride (a gaseous substance) contains at least some of the corresponding sulphurous acid, H_2SO_3. From sulphuric acid there is derived the series of salts called sulph*ates*, from sulphurous acid the series called sulph*ites*. It sometimes happens that an acid and series of salts are known of which the corresponding anhydride is unknown, just as the existence of certain acids is doubtful although the corresponding anhydride is known. In other cases series of salts are known, although both the corresponding anhydride and acid are unknown. Certain of these peculiarities, as well as some further forms of nomenclature, are illustrated by the table given below of the compounds corresponding to known or unknown oxides of chlorine:

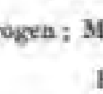
Oxide.	Acid.	Salt.	Name of salt.
Cl_2O	$HClO$	$KClO$	Potassium Hypochlorite.
—	$HClO_2$	$KClO_2$	" Chlorite.
(ClO_2, not an acid anhydride)			
—	$HClO_3$	$KClO_3$	" Chlorate.
—	$HClO_4$	$KClO_4$	" Perchlorate.

It has recently been proved that the substance described in most text-books as chlorous anhydride, Cl_2O_3, is really a mixture, and that as yet Cl_2O_3 has not been prepared. The hypothetical chloric and perchloric anhydrides would have the composition Cl_2O_5 and Cl_2O_7 respectively.

A very large number of salts and other chemical compounds are commonly known by popular names, the latter being frequently of extremely ancient origin. The popular name as a rule conveys no information as to the composition of the substance. For instance, copperas (ferrous sulphate, $FeSO_4$) is not recognised by its name as an iron compound, nor calomel (mercurous chloride, $HgCl$) as a mercury compound, nor litharge (lead oxide, PbO) as a lead compound. It is the aim to convey, by the systematic name of a substance, the greatest possible amount of information as to its composition. It is not possible to attain to a perfect system of nomenclature, as new discoveries render changes necessary from time to time.

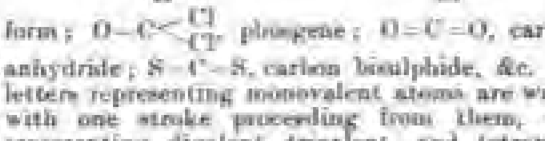
Graphic Formulæ.—In addition to representing the composition of a substance by means of formulæ, chemists endeavour to express certain ideas as to the *constitution*, or arrangement of the atoms in the molecule of substances by means of *graphic* formulæ. It must not be supposed (as has sometimes erroneously been done) that graphic formulæ are intended to represent the shape of molecules or the arrangement in space of the atoms constituting such molecules, but simply as a short method of expressing on paper certain facts. No one supposes that a printed word in any modern language is an attempt to draw the object spoken of, or that it is more than a method of representing on paper a given series of sounds, and yet criticism based upon assumption scarcely less absurd, has been directed against graphic formulæ. In a graphic formula we have the symbols for the different elements grouped in a particular way, so as (1) to indicate the *valency* (see the article ATOMIC THEORY) of each element, and (2) to express ideas based upon observed facts as to the most likely arrangement of the atoms in a molecule, when various arrangements are conceivable.

The following may be given as simple illustrations of (1):

H—Cl, hydrochloric acid; H—S—H, sulphuretted hydrogen; Mg=O, magnesium oxide; , ammonia; , marsh-gas; , chloroform; $\mathrm{O{=}C{<}^{Cl}_{Cl}}$, phosgene; O=C=O, carbonic anhydride; S=C=S, carbon bisulphide, &c. The letters representing monovalent atoms are written with one stroke proceeding from them, those representing divalent, trivalent, and tetravalent atoms being written with two, three, and four such strokes respectively.

Illustrations of (2) are:

Urea. Ammonium cyanate.



These two substances illustrate two other points of importance. One of these is the occurrence of the nitrogen atom sometimes *trivalent*, as in ammonia, NH_3, sometimes *pentavalent*, as in the ammonium salts—e.g. ammonium chloride, NH_4Cl. In ammonium cyanate one atom of nitrogen is represented as trivalent and the other as pentavalent. The two substances, moreover, illustrate *Isomerism* (q.v.), or the existence of two or more compounds containing exactly the same elements and in the same proportions, and yet differing from one another in chemical and physical properties.

Chemical Changes.—There are several kinds of chemical changes which are of very frequent occurrence, and may conveniently be classified. The simple union of one element with another has already been mentioned, and closely related to this kind of change is the union of a compound with an element or with another compound. Along with these changes may be classed those in which a compound breaks up into two or more elements or simpler compounds, or into one or more of each. All these variations are illustrated by the following equations:

$$\left.\begin{array}{l} C + O_2 = CO_2 \\ CO + Cl_2 = COCl_2 \\ CaO + CO_2 = CaCO_3 \end{array}\right\} \text{direct union.}$$

$$\left.\begin{array}{l} 2HgO = 2Hg + O_2 \\ (NH_4)_2Cr_2O_7 = Cr_2O_3 + 4H_2O + N_2 \\ Ca(HO)_2 = CaO + H_2O \end{array}\right\} \begin{array}{l}\text{decomposition} \\ \text{(by heating).}\end{array}$$

One of the most important kinds of chemical change is that called *double decomposition*. This occurs perhaps most frequently when solutions of salts are mixed with each other, and it is characterised by a mutual exchange of metal and salt radical. If an aqueous solution of sodium chloride be mixed with one of potassium bromide, although no visible change takes place, we have reason to believe that double decomposition goes on to a certain extent, with formation of some sodium bromide and some potassium chloride, whilst some of each of the original salts also remains, a state of equilibrium being eventually established amongst the four salts. If, however, one of the new products formed by double decomposition be insoluble or practically insoluble in water, as soon as any of it is formed it will appear as a *precipitate*, and be thus removed from solution, so that no condition of equilibrium can be established until formation of a precipitate no longer occurs—i.e. until the double decomposition is complete. Thus, if solutions of sodium chloride and silver nitrate be mixed in the proper proportions, the extremely insoluble silver chloride will be precipitated, and only sodium nitrate will remain in solution. The action may be represented by an equation:

$$NaCl + AgNO_3 = NaNO_3 + AgCl \text{ (precipitate).}$$

The action of sulphuretted hydrogen on many metallic solutions illustrates double decompositions in which the action is complete, as,

$$HgCl_2 + H_2S = HgS + 2HCl,$$

where the mercuric sulphide formed is insoluble in water, and is consequently obtained as a precipitate.

In connection with the subject of double decomposition the bearing of the law of Richter (already mentioned in the historical sketch) may be illustrated. Looking at the quantitative signification of the following equations,

$$KCl + AgNO_3 = AgCl + KNO_3,$$
$$NaCl + AgNO_3 = AgCl + NaNO_3,$$

we see that the quantity of chlorine which was united with 39 parts by weight of potassium or 23 of sodium to form a salt is exactly the quantity required to form a salt with 108 parts by weight of silver, whilst, similarly, the quantity of the group NO_3 which was united to these 108 parts by weight of silver is exactly the quantity required to form a salt with 39 parts by weight of potassium or 23 of sodium. The same holds good generally for double decompositions.

Another very important kind of chemical change is the displacement of one element in a compound by another. Chlorine, for instance, displaces the iodine in potassium iodide and takes its place;

$$2KI + Cl_2 = 2KCl + I_2.$$

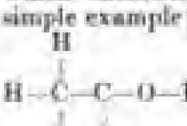
The greater affinity of potassium for chlorine than for iodine is the explanation given of this displacement. Displacement of one metal by another is a familiar phenomenon, although the chemistry of what is taking place may not be familiar to all who have seen it. When a piece of bright iron or steel, as a key or the blade of a knife, is dipped into an acidulated solution of cupric sulphate (blue vitriol), a reddish deposit of metallic copper is formed almost immediately upon the surface of the metal. This copper is derived from the cupric sulphate solution; but what is not manifest from observation alone, is that at the same time an equivalent quantity of iron is dissolved away and goes into solution as ferrous sulphate. The action is,

$$CuSO_4 + Fe = FeSO_4 + Cu.$$

The whole of the copper would eventually be separated from the solution in the metallic state if enough iron were present, and for every 63 parts of copper precipitated 56 parts of iron would go into solution.

Inorganic and Organic Chemistry.—The whole subject of chemistry has been divided into two great divisions, named respectively *inorganic* and *organic*. Made originally to separate from each other the chemistry of purely mineral substances, and that of substances of animal or vegetable origin, which were at the time supposed to be capable of formation only as products of vital processes, this subdivision is retained still mainly as a matter of convenience. The division of organic chemistry is sometimes spoken of now as the chemistry of the compounds of carbon; but this is not a very strict definition, as many carbon compounds occur in nature as purely mineral substances, and having really no connection with organic chemistry, such as numerous mineral carbonates. As has been already stated, it is mainly for convenience that the consideration of the majority of the compounds of carbon is taken as a separate branch, not because of any difference in the chemical principles involved, but really on account of the very great number of these compounds, and of the great complexity of many of them.

It is in the domain of organic chemistry that the study of the constitution of substances has been most diligently prosecuted, and with the greatest amount of apparent success. The graphic formula which chemists assign to acetic acid (to take a simple example) is,

 This formula is adopted in order to express a number of ideas concerning the supposed mode of arrangement of the atoms in acetic acid, deduced from the study of its formation, its decompositions, and the action upon it of various substances. The known facts find suitable expression in the formula, and there is no observation yet made as to the chemical relations of acetic acid which is at variance with the constitution indicated by it. It would not be possible here to quote evidence in favour of a particular constitution for any substance, but it may be stated generally that chemists endeavour to fix the constitution of the simplest compounds on the firmest possible basis, and, in passing from the simple to the more complex, to make secure every step.

The tetravalent character of the carbon atom, and the great facility with which carbon atoms enter into combination with other carbon atoms and with the atoms of other elements, give their impress to the whole of organic chemistry. The graphic formulæ of organic substances amply illustrate the former, whilst the syntheses of a long array of simple and complex organic compounds as amply illustrate the latter.

A certain amount of knowledge of chemistry is eminently useful in almost every walk of life. An intelligent knowledge of the chemistry involved in the processes of the kitchen, the dairy, the dye-house, the farm, or the manufactory, places the possessor engaged in any of these processes on a different level from the rule-of-thumb worker, who is as ignorant of the reason for adopting a particular method as he is of the properties of the materials he employs. Technical chemistry deals especially with the application of the principles and processes of chemistry to the arts and manufactures, and it is to those who are engaged in manufactures of almost every kind that a knowledge of chemistry is a particular advantage. It is not a question of expediency alone, but one of absolute necessity that a technical education, including chemistry as one of its principal subjects, should form not the least important part of the equipment for his work of any artisan who is to excel in his employment in intelligence and skill.

In connection with this article should be read the article ATOMIC THEORY, which is to a certain extent supplementary to this. ANIMAL CHEMISTRY and VEGETABLE CHEMISTRY are separately treated. The reader is also referred to the description of each element under its name, to those of the acids under their names, and to the following as amongst the most important of the large number of chemical articles throughout this work:

Acids.	Bases.	Glycerine.	Oxides.
Alcohol.	Bleaching Powder.	Isomerism.	Salts.
Alkalies.	Distillation.	Isomorphism.	Soap.
Alkaloids.	Elements.	Lime.	Starch.
Allotropy.	Ethers.	Metals.	Sugars.
Analysis.	Fats.	Oils.	Synthesis.
Aromatic Series.	Fermentation.	Organic Radicals.	Water.
Atmosphere.			

Chemists and Druggists. Up to the passing of the Pharmacy Act of 1868 the term chemist and druggist was merely a title descriptive of certain branches of trade, just as 'tailor and clothier,' or any other such combination. Any one was free so to describe himself and to prosecute that calling to the best of his ability, untouched by any special legislation, either regulative or protective. The class, like the Apothecary (q.v.), was in its beginnings closely allied to, if indeed at all distinguishable from, that of merchants and grocers, and never formed a distinct guild, and, until the Pharmaceutical Society was founded, was without permanent organisation. And owing to the absence in Scotland of the apothecaries, as a class distinguishable from druggists, the history of the latter class in that country does not, at least up to the passing of the Pharmacy Act of 1882, correspond accurately with that of their English brethren. The policy these latter pursued for a long period of their history may be described as purely defensive, and any organisation they formed was in response to some attack from one of the other orders. As early as 1802 such a defensive association was formed, and from 1812 to 1815 engaged in very active opposition to the bill promoted by the 'Associated Apothecaries.' One of the objects of that bill was to bring the chemists and druggists under the control and surveillance of a body consisting chiefly of apothecaries, on which the chemist and druggist was not represented at all. The upshot was that the promoters of the bill introduced a clause into the Act of 1815, which it was understood at the time would completely exempt the chemist and druggist from the operation of the bill. In spite, however, of this understanding, which seems to have been respected for twenty-six years, the bill was in 1841 made use of to punish a chemist and druggist for prescribing medicine, although that was a function which, rightly or wrongly, he had exercised previous to 1815. In 1841 a bill again threatened to subject the chemist and druggist to the control of the apothecaries, but was at length defeated. It now became evident, not only that a permanent society to protect the interests of the craft was necessary, but that the only wise policy was to educate and organise themselves in such a way as would deprive the physicians and apothecaries of any excuse for further interference. This led to the formation of the Pharmaceutical Society of Great Britain, which was founded in 1841 and incorporated by Royal Charter in 1843. As declared in the charter, the main objects of the society were those of 'advancing chemistry and pharmacy and promoting a uniform system of education of those who should practise the same; and also for the protection of those who carry on the business of chemists and druggists;' and to enable it to carry these out successfully the society appointed professors and examiners, and afterwards proceeded to promote a bill in parliament for the recognition and protection of the titles they proposed to confer on those who passed the examinations. This was naturally a work of time, and in the meanwhile an important act in relation to the sale of poisons—viz. the Sale of Arsenic Act (1851)—was passed, and drew the attention of government to the absence of a definite class of persons qualified by training and education to have the custody and sale of poisonous substances intrusted to them; so that this to some extent led up to the passing of the first Pharmacy Act of 1852. The main result of this act was to create a class of 'Pharmaceutical Chemists,' alone empowered to use and exhibit that or any equivalent title, and consisting, 1st, of those already members of the society; and 2dly, of such persons as should pass the examinations, as conducted by its two Boards in England and Scotland. The bill, as passed, involved no compulsion on any persons to go through these examinations, nor did it confer any privilege or monopoly on the pharmaceutical chemist except the exclusive right to that title. The dispensing of medicines and sale of poisons was still left open to any one who chose to engage in it. Nor was it till the Act of 1868 that the term chemist and druggist came to signify a specially qualified person or one possessing exclusive rights. By that act all persons not in business on their own account prior to 1st August 1868, had (except some who for a time were allowed to pass a 'modified examination') to pass two Preliminary and the Minor Examinations, and after that were entitled to have their names placed on the 'Register of Chemists and Druggists for the United Kingdom;' and no person who was not on that register could legally use the title, or (with certain exceptions in favour of physicians, apothecaries, veterinary surgeons, &c.) sell or dispense certain poisons specified in schedules to the act. Any person wishing to use the style 'Pharmaceutical Chemist,' had to pass a further examination called the 'Major,' and thus arose the two grades in what we may now call, in view of its educational qualification, the profession of pharmacy.

Chick Pea (*Cicer*), a genus of the vetch tribe of *Leguminosæ*. The common chick pea (*C. arietinum*) is an annual, 1½ to 2 feet high, of a stiff upright habit, covered with glandular hairs, with inflated pods containing a few angular and wrinkled peas. It is largely cultivated in southern Europe and in many parts of the East, and hence occurs frequently also as a weed in cornfields. It is also grown in Spanish America. Large quantities of the peas are exported from British India under the name of *gram*, now well known in commerce; but the name is extended to other East Indian kinds of pulse. The peas are used as food, either boiled or roasted, and are the most common *parched pulse* of the East. They are a notable article of Spanish and French cookery; while their importance in Roman times is evidenced by the phrase, *fricti ciceris emptor* ('buyer of roasted chick peas'), as a conversational equivalent for a poor fellow. Its cultivation extends as far as southern Germany; but in the climate of Britain it is found too tender to be profitable. The herbage affords fodder, and the seeds are one of the occasional substitutes for coffee. In summer weather drops exude from this plant, which, on drying, leave crystals of almost pure oxalic acid. The too free and prolonged use of chick peas as food is believed to be liable to become the cause of dangerous and obstinate forms of disease.

Chickweed (*Stellaria media*), one of the most common weeds of gardens and cultivated fields, is a species of Stitchwort (q.v.). It is a native of most parts of Europe and of Asia, appearing during the colder months even on the plains of India; an annual, with a weak procumbent stem and ovate leaves, very variable; some of the smaller varieties in dry sunny situations sometimes puzzling young botanists from having no petals or only five or three instead of ten stamens; but always characterised by having the stem curiously marked with a line of hairs, which at each pair of leaves changes from one side to another, and in four changes completes the circuit of the stem. The leaves of chickweed afford a fine instance of the *sleep of plants*, closing up on the young shoots at night. Chickweed is a good substitute for spinach or greens, although generally little regarded except as a troublesome weed, or gathered only by the poor to make poultices, for which it is very useful, or for feeding cage-birds, which are very fond of its leaves and seeds. A number of species of a nearly allied genus, Cerastium, also bear the name of Chickweed, or Mouse-ear Chickweed, and the name is occasionally given to other plants, either botanically allied, or of somewhat similar appearance.

Chicory, or SUCCORY (*Cichorium*), a genus of Compositæ (sub-order Liguliflora), with few species, all herbaceous perennials, with spreading branches and milky juice, natives of Europe and West Asia.

Chicory (*Cichorium Intybus*):
a, single flower; *b*, a separate floret.

The Common Chicory or Succory (*C. Intybus*) is wild in England and most parts of Europe, growing in waysides, borders of fields, &c. It has a long carrot-like root, externally of a dirty or brownish-yellow colour, and white within. The stem rises 1 to 3 feet, the leaves resembling those of the dandelion; the flower-heads are sessile, axillary, large (1 to 1½ inch), and beautiful, generally blue, more rarely pink or white. Chicory is pretty extensively cultivated, both in England and on the continent of Europe, as also in California, for its roots, while its herbage is good food for cattle. The blanched leaves are sometimes used as a salad, and are readily procured in winter by placing the roots in a box with a little earth in a cellar. To this genus belongs also the Endive (q.v.).

Chicory has been used as a substitute for coffee, or to mix with coffee, for at least a century. The roots are pulled up, washed, cut into small pieces, and dried on a kiln, which leaves a shrivelled mass not more than one-fourth the weight of the original root. It is then roasted in heated iron cylinders, which are kept revolving as in coffee-roasting, during which it loses 25 to 30 per cent. of its weight, and evolves at the same time a disagreeable odour, resembling burned gingerbread. An improvement to the chicory during roasting is the addition of 2 lb. of lard or butter for every cwt. of chicory, which communicates to it much of the lustre and general appearance of coffee. It is then hand-picked, to remove chips of wood, stones, &c., and is reduced to powder, and sold separately as *chicory powder*, or is added to ordinary ground-coffee, and is sold as a mixture. Chicory contains a good deal of sugar, but otherwise does not serve to supply the animal economy with any useful ingredient. It gives off a deep brown colour to water when an infusion is made, and hence its main use in coffee. Some people dislike the taste of chicory, and when largely used, it has a tendency to produce diarrhœa; but many people prefer to use coffee mixed with chicory owing partly to the taste it communicates, but mainly to the appearance of strength which it gives to the coffee.

Chigoe, or JIGGER (*Sarcopsylla penetrans*), a genus of flea, somewhat smaller than the familiar Pulex, and without its jumping legs. It is an American pest, found for about 30 degrees on each side of the equator, but especially abundant in the West Indies and in the north of South America. It is found also in the West African coast region. One of its many names—the 'sand-flea'—indicates its favourite haunt among sand. It seems always to keep near the abodes of men. The males and immature females live like other fleas on chance bites, and relish of course the blood of animals as well as of man. It is the impregnated female which is the chief trouble. Like many other animals it seeks a safe and quiet breeding-place. This is found under the skin of animals, on the feet or

Chigoe (*Sarcopsylla penetrans*):
a, male; b, gravid female.

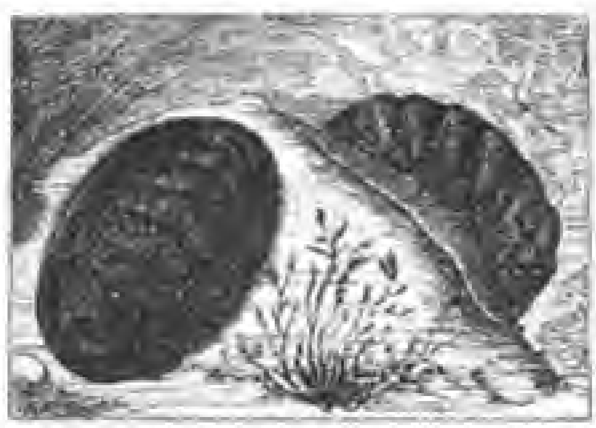
under the toe-nails of man. There the minute creature swells up enormously, attaining under the pressure of the growing eggs the size of a pea. Respiratory communication with the outer world is kept up by an air-hole at the posterior end. In less than a week the eggs are ready to be liberated, for the larvæ are not parasitic. The mother-animal has meanwhile undergone a marked degeneration, the internal organs being much squeezed and atrophied by the growth of the ova. The entrance of the female chigoe is marked by a tingling and itching sensation, but if the development be allowed quietly to proceed no evil results seem to follow. Pressure and premature attempts to isolate the intruder may, however, lead to ulceration. Its evil effects seem to have been exaggerated. When the development of eggs has been completed, the entire animal with its progeny may be gently removed, and in this operation the West Indian negresses are experts. Washing with tobacco-juice is also resorted to, and the leaves are sometimes pressed on the feet as a preventive.

Chilblains are localised inflammations of the skin which occur in cold weather, and affect the parts farthest from the centre of the circulation—viz. the hands and feet, more rarely the ears or nose. They are at first bright red, but as they disappear assume a purplish tinge. Sometimes they break and give rise to ulcers, which are slow to heal. They occur most frequently in young people, affect women more often than men, and are generally associated with weak health and a sluggish circulation. They are often extremely irritable and painful, especially when the affected part has been chilled, and is quickly warmed again. In their treatment, regard must be had to the general health; good feeding, exercise, and tonics should be prescribed. It is very important that tight shoes, gloves, garters, and bracelets should be avoided; and that the affected parts should be warmly covered when exposed to the open air. Locally, when the skin is whole, some stimulating agent answers best; tincture of iodine, spirit of camphor, or mustard applied moist and rubbed till it dries. If the skin be very tender, collodion painted over it is useful. Broken chilblains should be dressed with resin ointment or Peruvian balsam on lint.

Chitin, the substance which forms most of the hard parts of jointed-footed animals (arthropods), such as crustaceans, insects, and spiders. It was discovered by Odier in 1823, but regarded erroneously as free from nitrogen; rediscovered by Lassaigne in 1843; and since then recognised in all the four chief classes of arthropods and in some other types. Huxley has given an account of its formation in the crayfish. Chitin has been demonstrated in many arthropods, also in the pen of cuttle-fishes (Mollusca), and in the stalk and shell of *Lingula anatina*, a brachiopod. Its presence is at least probable in many other cases. In arthropods it is not confined to forming the firm and often very hard exoskeleton, but occurs internally in supporting plates, &c. among the tissues. In the crayfish it seems even to form the sheath of the strong ventral nerves. In arthropods the greater portion of the gut is formed as an intucking of the outer skin (ectoderm) from in front and behind, and the resulting portions known as fore- and hind-gut are also lined by this chitin, which frequently exhibit special internal thickenings for food-grinding purposes. The chitinous coating or cuticle is formed from underlying skin cells. In some cases the epidermic cells probably sweat it off after the manner of other secretions; but Huxley has shown in regard to the crayfish that the superficial portion of the cells undergoes a chitinous modification, being literally turned into chitin. The outer coat of crustacea is hardened by the addition of calcium carbonate or phosphate, especially the former; such calcareous hardening is very rare in insects, but copper has been demonstrated in some beetle cuticles.

Chitin is an amorphous white substance. It contains nitrogen, but is free from sulphur. Its resistance to acids and alkalies is very great; it is unaffected by digestive ferments, by water, hot or cold, by alcohol or ether. It may be dissolved by strong mineral acids (hydrochloric or sulphuric), and prepared from the cleaned exoskeleton of a lobster, or better still from the pen of a squid. Chemically it is regarded as a derivative of carbohydrates, and may be split up into sugar and glycosamin. According to Ledderhose, its formula is $C_{18}H_{30}N_2O_{12}$; according to Sundwik, $C_{60}H_{100}N_8O_{38} + nH_2O$.

Chiton, a genus of marine molluscs, type of an important sub-class which may be regarded as introductory to gasteropods. Unlike the lop-sided snails, the chitons are bilaterally symmetrical. The head is at the anterior end, the anus posterior; the 'foot' occupies the whole of the ventral surface; the heart, the gills, the excretory tubes, the genital ducts, all exhibit the same symmetry. This marked contrast to the gasteropods proper is further supported by the disposition of the two important nerve cords (pedal and visceral) which run parallel to one another along the body. In some forms there are numerous eyes, which occur, however, not on the head, but on the body. Another striking feature is the presence of a series of eight shell-plates along the back. On these and other grounds the chitons are separated from gasteropods proper, and established as a separate order, on which the



Chiton elegans.

name *Polyplacophora*, alluding to the multiple shell-plates, has been bestowed. Nor is the order a small one. Of the genus Chiton alone over 400 species have been recorded, and other smaller genera are also distinguished. The British species are small; those from warmer climates sometimes measure 3 to 4 inches in length. They are undoubtedly representatives of a primitive type, and include numerous fossil forms from the Silurian onwards. They are not, however, the simplest gasteropods, for a few other forms, known it is true with less fullness, exhibit the same essential features in even simpler expression. These are (*a*) the Neomeniæ, including the genera Neomenia and Proneomenia, and (*b*) the single genus Chætoderma.

Chloral (*trichloraldehyde*) is a limpid, colourless, oily liquid, with a peculiar penetrating odour, and is formed when anhydrous alcohol is acted on by dry chlorine gas. It dissolves sulphur, phosphorus, bromine, and iodine, and is closely allied to Aldehyde (q.v.). Chloral combined with one equivalent of water forms chloral hydrate, a white crystalline substance, with a pungent odour and a bitter taste, to which the name chloral is commonly though incorrectly applied. Chloral was discovered by Liebig in 1831, and investigated by Dumas; the chloral hydrate was first used as an anæsthetic and hypnotic by Liebreich in 1869. The chief action of a moderate dose of chloral (15 to 30 grains) is the production of sleep, closely resembling natural sleep, and usually sound and refreshing. It has also a marked effect in quieting excitement, as in insanity or delirium; and in relaxing spasm, and checking convulsions and allied conditions. Its action as an anæsthetic is very capricious and uncertain; medicinal doses sometimes relieve pain completely, but much more often fail to do so. It lessens the force of the heart's action, and in large doses greatly reduces the temperature of the body; and to these effects the fatal results that sometimes follow its administration are chiefly due. As a hypnotic it is most valuable in cases where opium or morphia is dangerous or undesirable (in children, in disease of the kidneys), and where sleeplessness is combined with excitement (delirium of fevers, delirium tremens, insanity); but it may be employed in many other cases with advantage. In tetanus (lockjaw), and other diseases attended by convulsions, it is often of great value. It acts as an antidote in poisoning by strychnia and Calabar bean. It must be employed with the greatest caution, or not at all where there is any reason to suspect weakness of the heart, or embarrassment of the circulation from any other cause; in such cases dangerous symptoms are very readily produced by it. When habitually employed to procure sleep, it is generally less hurtful than opium; but sometimes 'profound melancholy and enfeeblement of the will, muscular lassitude, inability to sleep without the drug,' and other untoward symptoms (called collectively *chloralism*) result, and only disappear when its use is discontinued. Moreover, fatal accidents from its indiscriminate use are far from uncommon. Poisoning by chloral should be treated by keeping the patient warm, attempting to rouse him, administering coffee and small doses of strychnia or atropia.

When chloral hydrate is treated with caustic potash, pure chloroform is obtained; but owing to the expense, this process has not come into use in Great Britain. It has been supposed that its anæsthetic property is the result of a similar formation of chloroform in the blood, but no evidence of this is forthcoming.

Chlorantha'ceæ, a small group, chiefly tropical, allied to the peppers, aromatic and stimulant. *Chloranthus inconspicuus* is the Chu-lan of the Chinese, who use it for perfuming teas.

Chloric Acid, $HClO_3$, is the acid corresponding to the hypothetical oxide of chlorine, represented by the formula Cl_2O_5. It is a syrupy liquid, with faint chlorine odour and acid reaction. A piece of paper dipped into it becomes charred and takes fire, and it is instantly decomposed by contact with organic matter. In itself it is not of much importance, but it forms a class of salts called *chlorates*, one of which at least is well known. *Chlorate of potash*, $KClO_3$, is an article of commercial value, and may be prepared by passing chlorine into a solution of caustic potash, heating the liquid, and crystallising out the salt. It forms pearly plates, which, when heated, melt and give off oxygen in abundance. So also when thrown on red-hot charcoal, oxygen is given off, and violent deflagration ensues. On account of this property it is used in the preparation of coloured fires, but its use is not unattended with danger, owing to their tendency to spontaneous combustion and its explosive properties when triturated with sulphur. Mixed cautiously with amorphous phosphorus, previously moistened with alcohol, it forms a mixture which, when dry, explodes if tapped with a pencil. This mixture is employed in the manufacture of some kinds of matches, which give a slight explosion when struck. If a crystal of chlorate of potash be placed on a piece of paper saturated with turpentine, and a drop of sulphuric acid added, it causes the inflaming of the turpentine with explosive rapidity. The chlorate is also used in medicine, and in a compressed form has become a popular remedy in certain forms of sore throat.

Chlorimetry is the process of estimating the proportion of 'available chlorine' in Bleaching Powder (q.v.), which may vary from 20 to 40 per cent. The term *available* applies only to that portion of the chlorine which is easily liberated, and which takes part in the bleaching process. Chlorine, which is present as chloride, as in chloride of calcium, $CaCl_2$, has no bleaching power, and is not estimated by chlorimetry.

The process is one of volumetric analysis, and the apparatus used is similar to that described in the article on Analysis (q.v.). There are several practical methods of chlorimetry, all based on the principle of measuring the oxidising power of the bleaching powder. This is arrived at by making a solution containing a definite amount of pure sulphate of iron, arsenious acid, or other substance capable of being oxidised, running in the solution of bleaching powder very slowly, and then by suitable tests determining the exact point when oxidation has taken place. By calculation the amount of 'available chlorine' is at once obtained. Where substances other than bleaching powder are under examination, slight modifications of the process may be necessary.

Chlorine (sym. Cl; atom. wt. 35·5; Gr. *chlōros*, 'pale green') is a non-metallic element discovered by Scheele in 1774, and named by him *dephlogisticated marine air*. Afterwards, in 1810, Davy proved it to be an elementary body, and gave it the name which it now bears. In nature it is always found in a state of combination. United with sodium, Na, it occurs very largely as the chloride of sodium, NaCl—common salt—in the ocean; in large beds, as rock-salt; in all natural waters, including even rain-water; in clays, soils, limestone; in volcanic incrustations; and in the vegetable and animal kingdoms. The preparation of gaseous chlorine by its liberation, directly or indirectly, from common salt, has been fully described under BLEACHING POWDER, which is the form in which chlorine is prepared and employed commercially. For experimental purposes the gas may be received in jars filled with warm water at the pneumatic trough, when the chlorine rises into the jar, and displaces the water. When thus obtained it is a yellowish-green gas with a peculiar and suffocating odour, is not combustible, and is a very feeble supporter of ordinary combustion. A lighted candle placed in it burns with a very smoky flame, owing to the hydrogen of the oil alone burning, while the carbon is liberated. Several of the metals, such as antimony, copper, and arsenic, in a fine state of division, or in the condition of thin leaves, at once become red hot, and burn when introduced into the gas. A piece of thin paper soaked in turpentine likewise bursts into flame. Chlorine is a very heavy gas, nearly 2½ times heavier than air, its specific gravity being 2·470 (air = 1·000); it is soluble in cold water to the extent of two volumes of chlorine in one of water, and yields a solution resembling the gas in colour, odour, and other properties. The principal properties of chlorine are those of a bleacher of cotton and linen (see BLEACHING) and a most powerful Disinfectant (q.v.). The gas can be condensed by pressure and cold into a transparent dark greenish-yellow limpid liquid, with a specific gravity of 1·330 (water = 1·000), which also possesses bleaching properties and a most powerful odour. On the animal system chlorine acts, in very minute quantity, by producing a sensation of warmth in the respiratory passages, and increasing the expectoration; in large quantity, by causing spasm of the glottis, violent cough, and a feeling of suffocation. The workmen in chemical manufactories, who get accustomed to the chlorine in small quantities, are generally stout—at least, lay on fat—but complain of acidity in the stomach, which they correct by taking chalk, and also suffer from the corrosion of their teeth, which are eaten away to stumps. The antidotes to the evil effects of the introduction of chlorine into the lungs are the inhalation of the vapour of water, alcohol, ether, or chloroform; but the latter two should never be resorted to except under medical supervision.

Chlorine forms with other substances a very large number of chemical compounds. Mixed with hydrogen in equal volumes, and exposed to sunlight or flame, union takes place with explosive energy, and hydrochloric acid, HCl, is produced. This acid forms an extensive class of salts called *chlorides* (see HYDROCHLORIC ACID), but many of these may be produced by the direct combination of chlorine with the metals, as in the experiments described above. Chlorine replaces other elements or groups of atoms in organic compounds, forming chloro-derivatives. In combination with carbon and hydrogen it forms many substances, among which Chloroform (q.v.) is perhaps chief. Chlorine forms with oxygen a series of oxygen acids—viz. Hypochlorous, $HClO$; Chlorous, $HClO_2$; Chloric, $HClO_3$; and Perchloric Acid, $HClO_4$; the more important of which are referred to under separate heads.

Chlorodyne is a patent medicine of considerable popularity, invented by Dr James Collis Browne (1819-84), but largely imitated by various chemists. It contains opium, chloroform, prussic acid, and probably Indian hemp, and is flavoured with sugar and peppermint. As it is apt to separate into two liquids on standing, it should never be taken unless it has previously been well shaken; and as, in taking a dose of chlorodyne, the patient swallows an unknown quantity of three or four of the deadliest poisons with which we are acquainted, it is always advisable to begin with small doses. It is unquestionably a compound which sometimes succeeds in allaying pain and inducing sleep when opiates have failed; but whether a physician is justified in recommending a remedy with the composition of which he is unacquainted is a doubtful question. To meet this difficulty the Medical Council, in the 1885 edition of the British Pharmacopœia, have introduced the tincture of chloroform and morphia, which practically represents chlorodyne. Five to fifteen drops is the average dose.

Chloroform, $CHCl_3$, was discovered as a chemical curiosity about the same time (1831) by Guthrie in America, Liebig in Germany, and Soubeiran in France. Soon, however, its properties as a stimulant when taken internally attracted attention, and when in 1847 it was brought into prominent notice as an anæsthetic by Sir James Simpson, it was at once recognised as one of the most valuable contributions of chemical science to suffering humanity. See ANÆSTHESIA.

Chloroform is composed of 12 parts of carbon, 1 part of hydrogen, and 106½ parts of chlorine. It may be produced in several ways, but in this country at least the process by which it is obtained from bleaching powder is the only one adopted on the large scale. The materials employed are bleaching powder, alcohol, and water. The bleaching powder and water are mixed together to form a thin cream, the alcohol added, and the whole placed in a capacious still, connected with suitable condensing apparatus. On the application of heat the contents rapidly froth up, and even though the external application of heat be stopped, the chemical action is so violent that the chloroform distils over rapidly along with water and any excess of alcohol. As so obtained it is very impure, and requires to be carefully treated with sulphuric acid, and then redistilled before it is fit for anæsthetic purposes. Pure chloroform is a limpid, mobile, colourless, volatile liquid, with a characteristic odour, and a powerful sweetish taste. When diluted with alcohol it enters into the composition of artificial fruit-essences, to which it gives a flavour akin to that of ripe apples. It is a very heavy liquid, its specific gravity being about 1·500 (water = 1·000), and as it does not readily mix with or dissolve in water, it falls to the bottom when poured into a vessel of that liquid, forming a distinct layer. Chloroform is readily miscible with alcohol and ether, and it dissolves camphor, amber, gutta-percha, wax, black and red sealing-wax, iodine, and bromine, as well as strychnine and other alkaloids. It dissolves a small proportion of water, being also slightly soluble in that liquid. Chloroform is not combustible in the ordinary sense of the term, but when its vapour is brought in contact with flame it burns, imparting a green tint to it, and irritating fumes are produced. Pure chloroform is not met with in commerce owing to the readiness with which it decomposes when exposed to light. In order to prevent this a small proportion of alcohol is added, the specific gravity being thus reduced from 1·500 to 1·497. When evaporated on the hand no disagreeable odour should be noticeable, and when shaken with sulphuric acid only a very slight discoloration of the acid (due to the small proportion of alcohol) should result. Besides its anæsthetic properties, which are elsewhere discussed (see ANÆSTHESIA), chloroform is used in medicine both externally and internally. When applied to the skin or any of the mucous membranes it acts as a powerful irritant, producing a burning sensation, and on this account it is of value as an application in rheumatism, lumbago, and neuralgia. As an application to a decayed tooth its action is twofold, as a stimulant and counter-irritant locally, and also to a partial extent as an anæsthetic. Taken internally, diluted with alcohol, it is a powerful stimulant, and readily produces a species of intoxication. It is by some habitually taken as a narcotic luxury. As chloric ether, a product distilled from bleaching powder, and containing chloroform, it enters into the composition of cough mixtures, pick-me-ups, &c.

Chlorophyll, as its name implies, is *leaf-green*, the ordinary colouring matter of vegetation. Microscopic examination of plant tissues shows it sometimes to tinge the whole protoplasm of the cell (though never the cell sap). Much more generally, however, it is collected into definite bodies, the so-called chlorophyll granules, or less frequently, as in some of the lower algæ, arranged in starlike masses (Zygnema) or spiral bands (Spirogyra). A brief immersion of the specimen in alcohol suffices to dissolve out the chlorophyll, and leave the form of the chlorophyll bodies unaltered; and the solution may then be conveniently studied in a fresh state, as it gradually fades on keeping. It is of a deep rich green by transmitted, but of characteristic deep red colour by reflected light; in a word, is highly fluorescent. The absorption-spectrum is quite characteristic; yet the complex nature of the substance is strongly argued for on the ground of the following experiment. Shake up the alcoholic solution with benzol, and when the two fluids have had time to separate, we find the green to have disappeared. The lighter alcohol above is now of a strongly yellow hue, while the subjacent benzol is of a distinctly bluish green. To these colouring matters the names *Xanthophyll* and *Cyanophyll* are commonly given. While their separate spectra are quite characteristic, their combined spectrum seems to restore that of chlorophyll. The latter substance resembles the blue-green colouring matter of some of the lowest algæ (Oscillatoria, &c.), while the yellow substance recalls that of many buds and flowers. Others, however, maintain that these substances are really the result of a destructive decomposition of true chlorophyll; while Gautier has even prepared green needle-like crystals which he regards as chlorophyll in a pure state. The chemical composition of chlorophyll is also a matter of considerable difficulty, both on account of its own easy decomposability, and its being necessarily accompanied by other extractive substances; thus the question of the presence or absence of iron has been much debated, a matter which seems to indicate variability of composition. This is further borne out by the labours of spectroscopists. Thus in addition to the familiar well-defined analogous colouring matters which characterise respectively the blue-green algæ, the brown and the red (see SEAWEEDS), researches such as those of Sorby and others seem to indicate a number of varieties too numerous even for enumeration. This varietal range, however, may best be approached after considering the conditions in which chlorophyll is formed. Of the chemical factors little can be said save that the presence of iron in the soil seems to be quite indispensable; the physical conditions are, however, simpler.

A sufficient temperature is necessary to the formation of chlorophyll; for seedlings from 4° to 8° C. being a minimum, while the process is said to take place most rapidly, on the average, at about 35° C. The most important condition is, however, the presence of light; with rare exceptions, plants cannot form any chlorophyll in darkness. The blanching of celery or leeks is a familiar instance of this, or conversely, the green coating acquired by a potato-tuber where it happens to have been denuded of its covering of earth. Shoots formed in darkness form colouring matter indeed, but only of a pale-yellow hue, the so-called *etiolin*; after a very brief exposure to light, especially if direct sunshine, chlorophyll appears, apparently by direct transformation of the former. The other colouring matters of plants are sometimes in protoplasm granules (chromoplasts), but more frequently also in solution in the sap; and these frequently are present in such abundance, especially in the epidermis, &c., as to mask the chlorophyll altogether, as happens especially in so many of our hothouse plants with decorative leaves. The general tendency of research is to indicate that all the phenomena of plant colour seem intimately connected with what we may term the general life-history of chlorophyll. Thus the yellows and reds of young shoots and leaves in spring may be interpreted as having some relation to the development of chlorophyll, if not absolutely stages of the process; while the same suggestion arises with regard to the colouring matters of flowers, which are similarly to be regarded as imperfectly vegetative shoots, although in this case through the onset of the reproductive function, instead of merely by reason of immaturity. Finally also with regard to the autumnal hues, in which the chlorophyll pigment seems to be disintegrating through colour-stages analogous to those of its evolution in spring, or of its arrestment in the flower. In favour of such a view evidence is forthcoming from either end of the vegetable kingdom. Thus Cienkowsky has shown that in the case of certain unicellular algæ, which like the common Protococcus of rain-water, possess red pigment as well as green when passing into the resting stage, the quantity of red may be increased in proportion as autumnal conditions are reproduced by artificially lowering the temperature, and *vice versâ*. The same experiment may be made with the common Sempervivums, Sedums, &c., whose leaves become more or less red in autumn or winter; those of Thuja (*Arbor Vitæ*) similarly become brownish, but recover themselves in spring. Among almost all cultivated plants, *variegated* varieties tend to arise, that is to say, we have certain cell areas of the leaf-parenchyma destitute of chlorophyll. The conditions of this are obscure (see VARIEGATED PLANTS); but it is noteworthy that this loss of chlorophyll may also take place in lower plants, so that there is considerable ground for regarding at least many apparent fungi as simply algæ which have degenerated in this respect through parasitism. Phanerogamous parasites like Toothwort (q.v.) or Dodder (q.v.) similarly become almost completely blanched.

Chlorophyll apparently identical with that of green parts of plants, can be experimentally demonstrated in the tissues of certain animals; and although this has in many cases been shown to be due to the presence of symbiotic algæ (see SYMBIOSIS), there remain cases—e.g. *Hydra viridis*, &c., and at the very least *Paramœcium virale*, in which we have undeniably intrinsic chloropayll, and this of truly vegetable function.

The development of our knowledge with respect to the functions of chlorophyll is still far from complete, and may in any case be more conveniently treated under LEAF and VEGETABLE PHYSIOLOGY (q.v.); suffice it therefore to state here the elementary and essential fact that its presence is in every case constantly associated with the process of *assimilation*, or elaboration of new products by help of the energy of sunlight, upon which the continued nutrition of the green plant depends; and of which the formation of starch with decomposition of carbonic anhydride and disengagement of oxygen are the most obvious chemical results.

Choke-damp, also called *after-damp* or *foul-damp*, is the carbonic acid gas given off by coal which accumulates in coal-mines, and may suffocate those exposed to it. It is distinguished from *fire-damp*, the marsh-gas or light carburetted hydrogen which causes the explosions.

Cholesterin, $C_{26}H_{44}O$, is a fatty substance, originally found in gall-stones, but now known to be present in the yolk of egg, the blood-corpuscles, milk, and other animal fluids, as well as in peas, barley, rye, &c. It is soluble in alcohol and ether, and separates from its solutions in glistening nacreous scales.

Chromium (sym. Cr, atom. weight, 52·5) is a metal, so called (*chroma*, 'colour') from the many-coloured compounds it produces. It was discovered by Vauquelin in 1797, in the chromate of lead, $PbCrO_4$, one of its rarer ores. As chrome iron ore, $FeOCr_2O_3$, it is extensively distributed in America, Sweden, Hungary, &c.

The metal has been obtained in several modifications, one of which is so refractory as to be infusible at a temperature sufficient to volatilise platinum, while it may be heated to redness without oxidation, and resists the action of most acids. Another variety is a powder which burns brilliantly when heated in air, and is readily dissolved by acids. The metal itself has not been employed in the arts, but many of the chromates are much used in painting and colouring. Chromium forms four compounds with oxygen, of which the chief are chromic oxide, Cr_2O_3, and chromic acid, CrO_3.

Chromic oxide (chrome green) possesses a bright-green colour, and is the colouring ingredient in the emerald. Owing to its indestructibility by heat, it is used in porcelain-painting; while, being non-poisonous, it is now introduced as a substitute for the dangerous arsenical green pigments which were formerly universally employed in the manufacture of wall-papers.

Chromic acid or anhydride, CrO_3, forms dark-red crystals, containing no water. When strongly heated it becomes incandescent, and is converted into chromic oxide. It forms several classes of salts: the *Chromates*, such as chromate of lead, $PbCrO_4$; the *Bichromates*, of which bichromate of potash, $K_2Cr_2O_7$, or K_2O2CrO_3, is an example; and the trichromates and tetrachromates, which are unimportant.

Chromate of Lead, $PbCrO_4$, is well known to artists as 'chrome yellow.' It is readily prepared by mixing a solution of acetate of lead with one of chromate of potash. When boiled with lime, its bright-yellow colour disappears, and a scarlet basic chromate is obtained, which is used in the dyeing of calico.

Bichromate of Potash, $K_2Cr_2O_7$, is prepared from chrome ironstone, by calcination with chalk and carbonate of potash, and subsequent treatment with nitric acid. It forms large red crystals, and has many uses in the arts. When added to a solution of gelatine and allowed to dry, it is found that on exposure to light the gelatin becomes insoluble, and a process based on this property has been used to some extent in photography. As an oxidising agent in galvanic batteries it is very effective, while mixed with sulphuric acid it is used in the bleaching of oils.

Chromic acid and its salts are all more or less poisonous, owing to their corrosive and oxidising action on organic tissues.

Chrome Steel containing a small and variable percentage of chromium, is highly valued in America for its toughness and strength.

Churns are machines used for the production of butter from cream or from whole milk. By agitation the butter globules are thrown against each other until after a period which varies in length with the quality of the butter-fat, the temperature, and the condition of 'ripeness,' or incipient acidity of the cream. Churns are of great variety in form and dimensions, from the ladies' glass hand churn producing a few ounces of butter at a time, to one driven by water, steam, or horse-power, and churning the whole milk of a dairy at one operation. The *plunge* churn or *thump* churn is one of the oldest and most simple varieties. The common *upright hand* churn seen in country places is perhaps the best known form of it, but the principle is equally applicable to larger churns. The *box* churn, either oblong or cubical, is stationary like the latter, the action being brought about by 'dashers' or 'works' made to revolve on a horizontal spindle passing through its centre.

Revolving churns, taking the shape of a box or barrel, are supported from two points on a rigid framework, so that the whole body of the churn is turned round at the rate of forty to fifty revolutions per minute by a crank handle after the fashion of an ordinary grindstone. Sometimes the motion is a simple rotatory one, as when the barrel is supported from the centre of both ends, giving it the position of a barrel rolling on the ground. It may also be hung from two corresponding points, one on each side, and occupy an upright position while at rest. The action is then called 'end over end.' An eccentric motion is given by hanging the body unevenly. These churns also contain 'dashers' or 'diaphragms' which increase the agitation of the cream. Their great advantage is the ease with which they can be worked—a matter of first importance where hand labour is employed. *Swinging* or 'cradle' churns are increasing in favour, because they are so extremely easily worked, inexpensive, and simple, and because they contain no movable 'dashers,' which demand much care and labour in keeping them sweet and clean. The body, consisting of an elongated box, may be suspended by four chains or thin iron rods, or it may be carried on four flat, flexible iron supports. It is pushed so that it swings backwards and forwards, giving the cream within a course which assumes the form of the figure 8. The *Holstein* churn is upright and rigid. Its dashers, which are attached to a perpendicular shaft, are worked at high speed. This enables the operator to reduce the temperature of the cream by nearly 10° F., as compared with the temperature at which it is put into an ordinary churn. Churning is then done in summer at 50° F., which gives the resulting butter-product much greater firmness and a better texture.

Chutney, an East Indian condiment, very largely used in India, and to a considerable extent in Britain. Indian chutney is a compound of mangoes, chillies or Capsicum (q.v.), and lime-juice, with some portion of other native fruits, such as tamarinds, &c., the flavour being heightened by garlic. It is sometimes manufactured for sale in England. Families occasionally make it for their own use, and employ the following ingredients: Chillies, 1 to 1½ lb.; apples, 1 lb.; red tamarinds, 2 lb.; sugar-candy, 1 lb.; fresh ginger root, 1½ lb.; garlic, ½ to ¾ lb.; sultana raisins, 1½ lb.; fine salt, 1 lb.; distilled vinegar, 5 bottles.

Chyle, CHYME. Food, having been partially digested and absorbed in the stomach, is then passed on into the small intestine. It is of a pulpy consistency, and is termed *chyme*. Both digestion and absorption continue in the small intestine (see DIGESTION). Of the digested chyme a portion finds its way directly into the blood-vessels of the intestine. Nearly all the fat, however, passes into a special system of Lymphatics (q.v.) termed *lacteals*. These lacteal vessels lie in the walls of the intestine, and, during the fasting condition, are filled with a watery-looking fluid called lymph, which exudes from the neighbouring blood-vessels. During absorption, however, the lacteals, in addition, become filled with the absorbed fat which is in a state of minute subdivision. This gives the *chyle*, as it is now termed, a milky appearance. The lacteals convey the chyle into a large vessel, the thoracic duct, which finally conducts it into the large veins at the root of the neck, where it mixes with the blood. One may observe the lacteals on opening the abdomen of an animal killed some few hours after a full meal containing fat. When filled with chyle they resemble white threads branching in the substance of the mesentery—a membrane stretching between the intestine and the back of the abdomen. Microscopically chyle consists of a fluid containing minute fat-globules and a few corpuscles, similar to white blood-corpuscles. Chyle is alkaline in reaction, and coagulates when withdrawn from the body. It may be looked upon as lymph plus the fat which has been absorbed. It contains (1) Proteids, such as serum-albumen, serum-globulin, and fibrinogen. Fibrin is formed during the process of coagulation. (2) Fats—palmitin, stearin, olein, and also cholesterin and lecithin. (3) Extractives, notably urea and grape-sugar. (4) Salts, especially sodium-chloride.

Cicatrisation (Lat. *cicatrix*, 'a scar'), the process of healing or skinning over of an ulcer or broken surface in the skin or in a mucous membrane, by which a fibrous material of a dense resisting character, covered by a protecting layer of epithelium, is substituted for the lost texture. The new tissue in such a case is called the cicatrix, and usually resembles to a considerable extent the structure which it replaces; it is, however, less elastic, and from its shrinking in volume may produce an appearance of puckering. This shrinking sometimes leads to serious results, especially after extensive Burns (q.v.). The glands and other special structures of the original tissue are wanting in the cicatrix, which, however, performs perfectly well, in most instances, the office of protection to the parts below the surface. See INFLAMMATION and ULCERATION.

Cinnabar, an ore of mercury, from which almost all the mercury of commerce is obtained. Chemically it is a sulphide of mercury containing 86·2 parts of mercury and 13·8 of sulphur. It occurs both crystallised and massive, not unfrequently disseminated. Its crystals are six-sided prisms. It varies from perfectly opaque to almost transparent; has an adamantine, almost metallic lustre, and a carmine colour, with a bright scarlet streak. Its specific gravity is 8 to 8·2. *Hepatic Cinnabar*, so called from its liver-brown colour, is a variety containing a little carbon. Cinnabar sometimes occurs in primitive rocks, but more frequently in those of the coal formation. The cinnabar mines of Almaden, in Spain, have been worked for about 2300 years, and have been surpassed in productiveness by those of New Almaden in California. Cinnabar mines exist also in Idria, Germany, Hungary, Peru, China, and Japan. Cinnabar is used as a pigment under the name of *Vermilion*.

Cinnamic Acid, $C_6H_5CH = CHCOOH$, exists in the free state in the balsams of Tolu and Peru, in liquid storax, and in gum benzoin. When oil of cinnamon (see below) is exposed to the air, it absorbs oxygen and deposits crystals of cinnamic acid. Cinnamic acid forms colourless crystals readily soluble in alcohol, ether, and boiling water, but sparingly soluble in cold water. It is not of any importance in the arts, and is chiefly interesting as being the acid corresponding to oil of cinnamon. This oil is the aldehyde of cinnamic acid, and is represented by the formula $C_6H_5CH = CHCOH$. Although isomeric with oil of cassia, it has a slightly different flavour, and is much more expensive. Both of these oils are employed in medicine as aromatic stimulants, but chiefly as pleasant adjuncts to disguise the taste of nauseous drugs. From a chemical point of view, the cinnamic acid and oil of cinnamon are related to Benzoic Acid (q.v.) and Oil of Bitter Almonds (q.v.). Benzoic acid is regarded as C_6H_5COOH, while the oil of bitter almonds is the corresponding aldehyde C_6H_5COH. On oxidation cinnamic acid is changed into benzoic acid.

Circle, MAGIC, a space in which sorcerers were wont to protect themselves from the fury of the evil spirits they had raised. This circle was usually formed on a piece of ground about nine feet square (in the East seven feet appears to have been considered sufficient), in the midst of some dark forest, churchyard, vault, or other lonely and dismal spot. It was described at midnight in certain conditions of the moon and weather. Inside the outer circle was another somewhat less, in the centre of which the sorcerer had his seat. The spaces between the circles, as well as between the parallel lines which inclosed the larger one, were filled 'with all the holy names of God,' and a variety of other characters supposed to be potent against the powers of evil. Without the protection of this circle, the magician, it was believed, would have been carried off by the spirits, as he would have been had he by chance got out of the charmed space. Another figure which, described upon the ground, could bar the passage of a demon, was the *pentagram*. Readers of *Faust* will remember its effect upon Mephistopheles.

Circulation, **in Anatomy and Physiology, is the term used to designate the course of the blood from the heart to the most minute blood-vessels (the Capillaries, q.v.), and from these back to the heart. To simplify the consideration of the subject, we shall consider—(I.) the General Anatomy, (II.) the Comparative Anatomy, (III.) the Physiology, and (IV.) the History.**

I. The organs of circulation consist of the heart, arteries, veins, and capillaries. The course of the blood through these organs will be best elucidated by the aid of a diagram, which is equally applicable for all other mammals as well as for man, and for birds. The dark parts of fig. 1 represent the course of the impure or venous blood, while the lighter portions represent the course of the pure or arterial blood. Two of the four chambers of the heart (A and C) receive the inflowing blood, and are termed the *auricles*; while the other two chambers (B and D) drive the blood to the lungs and to the general system respectively, and are termed the *ventricles*. The vessels that bring blood to the auricles are termed *veins*, and the vessels through which the blood is driven from the ventricles are known as Arteries (q.v.). We will now trace the course of the blood, as indicated by the arrows of the diagram, commencing with the right auricle, A. The right auricle contracting upon the venous or impure blood **with which we suppose it to be filled, drives this into the right ventricle, B, through an opening guarded by a triple (or tricuspid) valve, which almost entirely prevents the regurgitation of the blood from the ventricle into the auricle. The ventricle, B, being now filled, contracts, and as the blood cannot return into the auricle, it is driven along the dark vessel, c, which is the pulmonary artery, conveying the blood *to* the lungs. At its commencement it is guarded by crescent-shaped (semilunar) valves, which entirely prevent the blood which has once been propelled into the pulmonary artery from re-entering the ventricle. The pulmonary artery gradually divides into smaller and smaller branches, which ultimately emerge into capillaries freely distributed over the interior of the air-cells of the lungs. There the blood gives off carbonic acid gas, and absorbs oxygen, becoming thereby 'pure.' The capillaries, in which the blood is purified, gradually unite to form larger vessels, and finally the blood is collected into the pulmonary veins, which pour their contents into the left auricle, C. Thence it is propelled into the left ventricle, D, through an opening guarded by a double (mitral or bicuspid) valve, which entirely prevents the reflux of the blood. The left ventricle contracts and drives its contents into the large artery, *e*, or Aorta (q.v.), which by means of its various branches supplies the whole body with pure blood. From the aorta and its various subdividing branches the blood passes into the capillaries, J, H, which occur in every part of the system. In these capillaries it parts with its oxygen to the tissues, and becomes charged with the waste carbonic acid gas. The capillaries unite into larger veins, and these gradually unite to form two large trunks, *a*, *b*, the superior and inferior *venæ cavæ*, which pour their contents into the right auricle—the point from which we started. The diagram also shows how the venous blood from the viscera, G, instead of passing directly into the** vena cava, goes through the liver, F, in what is known as the hepatic-portal system.

Fig. 1.—Diagram of Circulating System (from Leunis).

Before passing to the comparative study of the circulation, we must notice a few of the above facts in greater detail. The Heart (q.v.) is described in a separate article. Since all the arterial blood leaves the heart through the aorta, to trace the circulation of the pure blood involves following the branches of that great vessel. For this see AORTA. It is sufficient, without further anatomical details, to say that the ramifications of the arteries distribute the arterial blood to the Capillaries (q.v.) which pervade every part of the body. It is already evident that the pulmonary arteries from the right ventricle carry impure blood to the lungs, and that pure blood returns from the lungs to the left auricle by the pulmonary veins.

Fig. 2.—Theoretical Section of the Human Heart:

f, *b*, the two venæ cavæ, opening into *d*, the right auricle; *e*, the tricuspid valve; *a*, the right ventricle, from which proceeds the pulmonary artery, dividing into branches *g* and *i*, going to the right and left lungs respectively; *c*, *c*, the pulmonary veins (two from either lung), entering into the left auricle, *k*; *l*, the mitral valve; *m*, the left ventricle, from which proceeds the aorta, whose arch is indicated by *h*, and the descending portion by *n*, some of its branches being indicated in this figure; *o*, the partition, or septum, between the right and left hearts.

The *veins*, like the arteries, are found in nearly every tissue; they commence in minute networks **which communicate with the capillaries. Branches from these networks uniting together, form veins, which, by joining, increase in size as they pass onward towards the heart. If we except certain venous structures (called *sinuses*) occurring in the interior of the skull, we may divide the veins into two sets—the *superficial* or *cutaneous*, and the *deep* veins. The deep veins accompany the arteries, and are usually inclosed in the same sheath of tissue. In the case of the smaller arteries they generally exist in pairs, one on each side of the artery, while the larger arteries have usually only one accompanying vein. The superficial veins occur immediately beneath the integument; they not only return the blood from the skin and adjacent structures, but communicate with the deep veins. All the veins finally lead by two large trunks, the *superior* and *inferior vena cava*, into the right auricle of the heart. The superior vena cava is formed by the union of the veins from the head and neck (the jugulars) with those from the arms (the subclavians), while the inferior vena cava brings back the blood from the lower extremities, the trunk, and the viscera.**

We must refer to the article VEIN for the structure of the walls of this part of the circulatory system. There is only one point that imperatively requires notice here—viz. that while the arterial system presents no valves except at the points where the two great trunks leave the heart, the veins contain a great number of valves, which are formed by a doubling of their lining membrane, and resemble pocket-like folds or pouches, which allow the blood free passage toward the heart, but prevent its reflux. The veins are much less elastic than the arteries, and their total capacity is much greater.

There is one part of the venous circulation which, from its great importance, requires special notice —viz. that of the spleen, pancreas, stomach, and intestinal canal. The blood supplied to these organs by the cœliac and the two mesenteric arteries is not returned directly to the inferior vena cava, but passes by several veins into one large vessel—the portal vein, which enters the liver, and breaks up into a capillary network. There the blood undergoes important changes associated with the bile-secreting and glycogen-forming functions of the liver. The blood, entering the liver from two sources, from the portal vein and from the hepatic artery, leaves it by the hepatic veins, which join the inferior vena cava. It is also important to notice the entirely distinct set of vessels known as lymphatics, which conduct the products of digestion into the veins (see LYMPH).

The above-described double circulation (through the lungs and through the body) is exhibited by the blood from the time of birth during the whole period of life. The circulation of the blood, however, begins before birth—indeed, at a very early period of intra-uterine or fœtal existence; and the circumstance that before birth the lungs do not act as organs of respiration induces a very important modification in the course of the blood in fœtal life which will be described under FŒTUS.

II. *Comparative.*—The circulatory system in man, as above described, may serve as type of the highest development, differing but slightly from that of other mammals, or that of birds. It is convenient now to begin at the other end, and to note briefly the salient steps of progress in the gradual evolution of the system throughout the animal series. In the unicellular animals the movement of the protoplasm and the special activity of 'contractile vacuoles,' represent, to some extent at least, a circulatory function before the appearance of any system. The canals which so completely irrigate a sponge, likewise illustrate in low expression a circulatory system not yet separated off from the others. In Cœlenterates, too, the system is still unseparated: 'gastro-vascular' prolongations of the alimentary cavity penetrate the body, as may be very well seen in the disc of a common jelly-fish. In the lower worm-types also, where no distinct body-cavity is yet developed, the nutritive fluid simply diffuses through the body, and no vascular system is differentiated. But in higher worms there is generally a body-cavity, and with it the gradual appearance of a definite vascular system. In some we simply find a fluid moving in the body-cavity, occasionally clear, usually with corpuscles; in others, portions of the body-cavity are separated off as blood-spaces, or eventually as blood-vessels; these may remain in connection with the general cavity, or may at length form a closed system. The manifold worm-types afford abundant illustration of all the stages in this differentiation. In the bristle-footed worms (Chætopods, q.v.), and in some others, the perfecting of the blood-driving mechanism may be instructively traced. Often a dorsal vessel is diffusely contractile, less frequently the ventral; or there may be contractile connecting loops between dorsal and ventral vessels, as in the earthworm; or lastly, a special region in the dorsal vessel may become the main seat of the vascular contractility. Such a *dorsal* heart is found from this point onwards throughout the Arthropods and Molluscs. (The well-developed and very difficult vascular system of Echinoderms, which co-exists with an abundant body-cavity fluid with relatively few corpuscles, has no special interest for this general survey.) In crustaceans, the dorsal heart, usually inclosed in a special space or 'pericardial sinus,' drives blood by more or less well-developed arteries through the body. The rest of the system is best described as lacunar. The venous blood passes along body-cavity spaces to the gills for purification, thence returns to the pericardial sinus, and entering the heart is redistributed. In insects a chambered dorsal heart, inclosed in a sinus as before, drives the blood forward, but as one would expect from the very efficient respiratory apparatus, the general vascular system is but slightly differentiated. The blood, purified by diffusion from the everywhere present air-tubes, passes back by venous channels into the sides of the pericardium and heart. In myriapods, scorpions, and king-crab, the system is more definitely developed, but illustrates no new advance except that of more complete establishment and wider extension of vessels. In molluscs, however, some progress is observable. Except in the Elephants' Tooth Shell (Dentalium), a heart is present, and the arterial system is often very well developed, even to the extent of capillaries in some cuttle-fishes and snails. Usually, however, the venous blood travels along lacunæ, though gradual transitions occur between these and true veins. The blood purified in the gills or pulmonary chamber passes back into a special portion of the body-cavity—the pericardium, and thence into the heart. In certain worm-types,

several contractile lateral vessels may often be observed to enter the dorsal vessel; in the Pearly Nautilus, which has four gills, four efferent vessels dilating into four indistinct auricles, enter the median dorsal heart or ventricle; in almost all bivalves the entrant dilatations or auricles are reduced to two, one on each side; while in most Gasteropods and Pteropods the specialisation has gone further, and the heart consists of a single auricle and a thicker muscular ventricle. The latter drives the blood through the body by a single or double aorta.

Passing now with equal brevity through the vertebrate series, we notice first that the heart arises as a dilatation no longer of a dorsal, but of a *ventral* vessel. Up to and including amphibians, the heart begins as a specialisation of the 'sub-intestinal vein' in the throat region; in most, if not all higher vertebrates, it arises from the fusion of two vessels. It always lies in a pericardial sac.

(1) Among the degenerate Tunicata there is considerable variety in the vascular system. In one case no heart is present; in several there are no definite vessels or blood-corpuscles. The main point, however, is that in most cases a tubular ventral heart drives blood to the respiratory pharynx. In all cases where the heart has been observed, the direction of its beats has been seen to undergo reversal at regular short intervals, a phenomenon which has also been noticed as a rarity in certain worm-types.

(2) The vascular system of the lancelet or amphioxus is of a peculiarly diffuse and undifferentiated nature. It has in one sense no heart, in another sense many; for while there is no main centre of contractility, there are small pulsating dilatations at the bases of the vessels passing to the gill-slits, while the portal vein and ventral vessel in the anterior pharyngeal region are both said to be contractile. In general course, the circulation is like that of a fish; the blood passes from ventral vessel to respiratory region, thence to dorsal aorta, thence to body, thence by united sub-intestinal veins to the liver cœcum, and thence to the ventral vessel from which it started.

(3) In the Round Mouths (Cyclostomata) the typical fish-circulation is established. The muscular ventricle drives the blood by a ventral vessel ('ventral aorta') to the gill-sacs; thence the purified blood is gathered into efferent dorsal vessels, which form in uniting the 'dorsal aorta.' The latter gives off branches to the greater part of the body, the head-region being directly supplied from the anterior efferent branchials. The blood returns from the anterior and posterior regions into a uniting vessel behind the heart ('the *sinus venosus*'), thence into the receiving auricle, and from that to the muscular ventricle.

(4) It is enough after the above to notice in regard to the fishes proper, that with the exception of the double-breathing mud-fish (Dipnoi), the heart never contains anything but impure blood, that it drives this wholly to the respiratory organs, and is in no direct degree 'systemic.' The 'dorsal aorta' supplying most of the body is formed from the union of efferent branchials, and does not arise, as in higher vertebrates, from the heart. It is important to notice that the five or so arches which spring from the ventral aorta are almost all quite alike, and arise (except in Dipnoi) at slight intervals from one another. A great part of the differentiation in higher vertebrates obviously concerns these aortic arches, which are seen in Cyclostomata and fishes in primitive uniformity, but become modified in higher vertebrates into the carotids, sub-clavians, aortic arches, and pulmonary arteries. The heart of a fish consists of the *sinus venosus* or general junction, running transversely behind the heart (persisting hence onwards, except in adult birds and mammals), of the auricle and ventricle, and except in Teleostei of a specialised contractile portion of the latter known as the *conus arteriosus*. A dilatation of the beginning of the ventral aorta is distinguished as the *bulbus arteriosus*. In regard to the general system, it is worth noticing that in fishes (as in amphibians and all reptiles except Chelonians) there is a renal portal, as well as an hepatic portal system. Veins from the caudal region of the fish come into the same relations with the kidneys as the portal veins do in regard to the liver. The hepatic veins returning from the liver do not unite with the other posterior veins, but enter the *sinus venosus* independently. Thus fishes have no *inferior vena cava*. (4*a*) The Dipnoi are interesting as leading on to amphibians. The

Fig. 3.—Arterial System of Fish:

H, heart; *c* and *c'*, anterior and posterior cardinal veins; *a*, branchial arteries; B, capillaries of the branchial vessels; *b*, branchial veins; *cc*, head circle; *ca*, carotids; RA, root of the aorta; A, dorsal aorta; E, artery to viscera (cœliaco-mesenterica); N, renal arteries. (After Wiedersheim.)

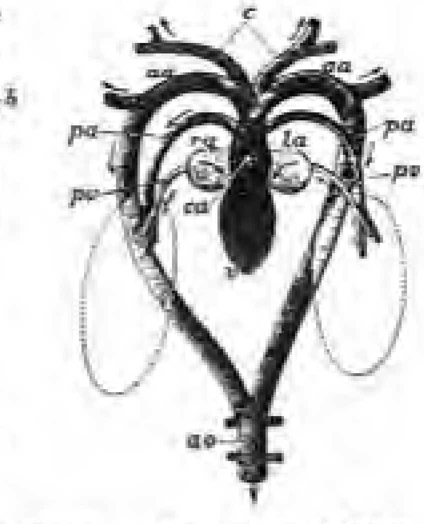


Fig. 4.—Arterial System of Amphibian:

ra, right auricle; *la*, left auricle; *v*, ventricle; *ta*, truncus arteriosus; *c*, carotid arteries; *aa*, aortic arches; *ao*, dorsal aorta; *pa*, pulmonary artery; *pv*, pulmonary vein; *ca* receives venous blood from body; both the pulmonary arteries enter *la*. (After Nuhn.)

heart receives pure as well as impure blood, drives blood to lungs in addition to gills, is in part systemic (driving pure blood in Protopterus and Lepidosiren through the first two pairs of arches), has the roots of the aortic arches close together, and is practically three-chambered. In these respects it reaches forward to the condition seen in those amphibians which retain their gills.

(5) The heart of amphibians is three-chambered, a right auricle receiving impure blood from the body, a left auricle receiving purified blood from the lungs or from the lungs and gills, a single ventricle which drives the blood, mingling less than might be supposed, to head or body or respiratory organs. In some cases, as one would expect, the partition between right and left auricle is imperfect. In the tadpoles at the fish-like stage there are four aortic arches, of which the first three supply gills. Where gills persist, such supply is always of course in some degree maintained. In such a metamorphosis as that of the frog, where all trace of gills is lost, the first branchial arch becomes the carotid; the second is the systemic, which forms, by uniting with its fellow, the dorsal aorta; the third dwindles away; the fourth supplies the lungs.

The same is generally true of the higher vertebrates, except that it is usually the third branchial which forms the pulmonary artery. An inferior *vena cava* is definitely established in amphibians; there is a renal portal as well as an hepatic portal system; special lymph hearts are sometimes present connecting the lymph system with the vascular.

(6) Among the reptiles, the differentiation of the heart goes a step further. In Chelonians, Lacertilia, and Ophidia, a strong muscular ridge forms an incomplete partition, dividing the ventricle into a right portion containing purely venous blood, and a left portion containing mixed and arterial blood. The pulmonary artery rising from the right cavity takes purely venous blood to the lungs; of the two aortic arches rising from the left cavity, the left aorta contains more venous than arterial blood, the right aorta more arterial than venous. In Crocodilia, however, there is a complete septum in the ventricle, and thus for the first time a four-chambered heart, though it is not certain that the division is exactly comparable to that of birds and mammals. From the right or venous ventricle rise the pulmonary artery and left aortic arch (taking venous, not mixed, blood to the viscera); from the left or arterial ventricle rises the right aorta, with pure blood to the greater part of the body. Though the division of arterial and venous chambers brings the crocodilian heart to the bird or mammal level, there are two aortic arches, one venous, the other arterial, which unite as usual, and also communicate by a foramen at their roots. In all reptiles there are two superior *venæ cavæ*, an inferior *vena cava* formed from the union of the two efferent renals, and a renal portal system except in Chelonia. In birds and mammals a single aortic arch forms the dorsal aorta, not two or more as in reptiles. In birds the aorta goes to the right, in mammals to the left, but except in this variation and in the structure of the Heart (q.v.), the circulation in Birds (q.v.) and mammals (*supra*) is practically identical.

III. *Physiology.*—The most important conditions of circulatory function are (1) a general constancy and rapidity of flow, and (2) a power of adapting this to special needs. The conditions of the former are mainly mechanical and physical—those of the latter depend upon the nervous system.

(1) *The Mechanism of Circulation* chiefly depends upon the rhythmic contractility of the heart, the elasticity of the vessels, and the friction in the small arteries and capillaries. The heart is a muscular pump contracting under the influence of its automatic nervous mechanism, but also responding in the nature of its beat to the conditions of the body. The human heart usually beats about seventy-two times a minute, and in the eight-tenths of a second occupied by each beat, three distinct events occur—the contraction (*systole*) of the ventricles, a 'passive interval' of relaxation (*diastole*) of both auricles and ventricles, and the decidedly briefer contraction of the auricles. The pumping action of the heart is thus obviously an intermittent force which drives the blood through the closed series of elastic tubes formed by the blood-vessels. To the latter attention must now be directed.

The *arteries* are surrounded by muscular tissue, and are contractile as well as highly elastic. As they break up into branches from the aorta to the capillaries, the capacity for holding blood is continually increasing. The flow of blood within them, though continuous, comes in gushes corresponding to the heart-beats. The velocity of the stream is greatest the nearer the heart. The *veins* are much less elastic than the arteries, and have a much greater total capacity for holding blood. As they unite from the capillaries to the venæ cavæ, the total capacity is continually diminishing. The flow of blood within them is continuous, but with relatively little force and small velocity. The *capillaries* have a very small calibre, but are both elastic and contractile. They are permeable by fluids, and also allow the corpuscles to pass through their walls. The velocity of the flow is here at its minimum. The resistance to the flow of blood, due to the friction of these minute passages, works back along the arterial system to the heart, and is one of the most important factors in determining the nature of the circulation.

To return now to the actual mechanism, it is only necessary to note (*a*) that the whole system is always over-filled with blood, which consequently causes a pressure on the walls; (*b*) that the cause of the circulation is the difference of pressure between the blood in the aorta and pulmonary arteries on the one hand and the venæ cavæ and pulmonary veins on the other; (*c*) that this difference of pressure is due to the contraction of the heart; and (*d*) that the interrupted current, which would naturally arise from the intermittent action of the heart, becomes continuous because of the rapidity of the beats, the resistance in the small arteries and capil-

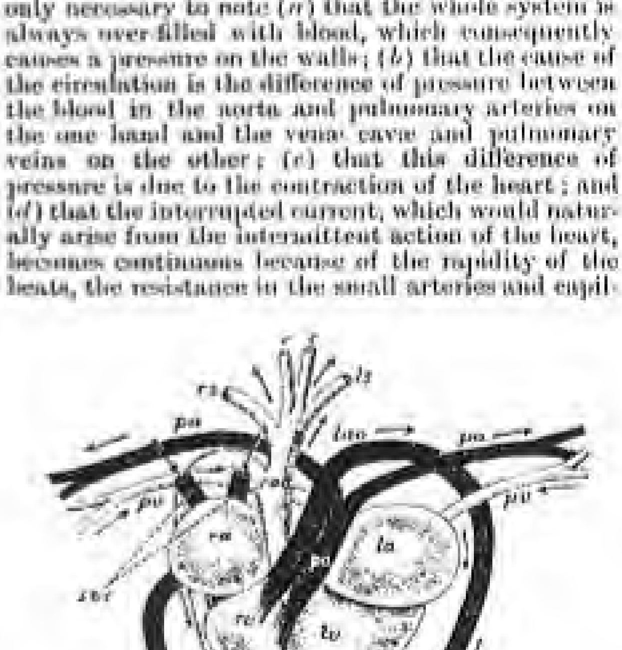


Fig. 5.—Circulation of a Reptile (Tortoise):

ra, right auricle; *la*, left auricle; *rv*, right (venous) portion of ventricle; *lv*, left (arterial) portion of ventricle; *lao*, left (venous) aortic arch; *pa*, pulmonary artery; *ra*, right (arterial) aortic arch; *rs*, *ls*, branches to fore-limbs; *c*, carotids; *pv*, pulmonary veins; *svc*, superior venæ cavæ; *ivc*, inferior vena cava; *ao*, dorsal aorta; *cal*, cœliac artery to viscera. (After Nuhn.)

laries, and the elasticity of the arterial walls.

(2) *The Control of the Circulation.*—The phenomena referred to above are mainly physical and mechanical, and in their essential features can be readily reproduced on a model. But in a complex living organism there is a constant necessity for modifiability. The organs vary in their requirements, and the external conditions are frequently changing. Modifications in the circulation are brought about by changes in the heart's beat, and in the calibre and resistance of the small arteries. Both these changes are under the direct control of the Nervous System (q.v.). Modifications of less importance also occur in the capillary resistance and in the total quantity of blood; but the important point is simply the general fact that the requirements of the organism are met by the dominion of the nervous system over the circulation.

IV. *History.*—Aristotle and the ancients thought of the heart as a blood-fountain, but had no conception of circulation. Galen (131-201) disproved the prevalent notion that the arteries contained air, Calvin's contemporary Servetus demonstrated the pulmonary circulation, and various physiologists had a distinct notion of the centrifugal flow. In 1628 William Harvey published his *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus*, in which his discovery of the real nature of the circulation was expounded. Soon after, the use of the microscope revealed to Malpighi (1661) and Leeuwenhoek (1674) what Harvey had been unable to trace—the capillary connection between arteries and veins. Since those days the detailed problems of circulation, the hydraulic mechanism, the action of the heart and its valves, and the nervous control have been worked at by many of the greatest physiologists.

Citric Acid, $H_3C_6H_5O_7$, is the acid to which lemon and lime juice owe their sourness. It also occurs, in some cases along with tartaric acid, in oranges, cherries, currants, gooseberries, and other fruits having a subacid taste. For practical purposes it is always obtained from lemon, lime, or bergamot juice, which contain it in large quantity. The first named of these contains from 20 to 40 grains of citric acid in each fluid ounce.

Citric acid is prepared from these juices by a very simple process. The juice having been heated to the boiling-point to clarify it from albumen, mucilage, &c., is mixed with chalk, $CaCO_3$, which, combining with the citric acid, falls to the bottom as citrate of calcium. The supernatant liquid being drawn off, sulphuric acid is added to the precipitate, decomposing it, with the formation of citric acid and sulphate of lime, $CaSO_4$. By crystallisation it may be obtained pure in the form of colourless, odourless prisms, which effloresce in dry air, and possess an agreeable acid taste and an acid reaction. It is readily soluble in water and alcohol, but almost insoluble in ether and chloroform. A solution of it in water cannot be kept owing to its tendency to ferment. Dissolved in syrup it keeps much longer, and is used largely in the manufacture of lemonade and other aerated beverages, communicating an acid, fruity taste. When heated, the crystals melt, then decompose, and are finally reduced to a combustible form of charcoal. In addition to its employment as a flavouring agent it is largely used in the manufactures. Calico-printers employ it for discharging the mordant from the cloth in patterns, and it is used in dyeing silk with safflower, &c.

Citric acid may also be prepared artificially, but the process is too complex ever to come into practical use. Chemically it is of great interest as exemplifying that as soon as the chemical constitution is known there is a possibility of producing the substance artificially. There is a popular idea that some day quinine, morphia, and other natural products will be formed by the random mixing together of chemicals in the chemist's beaker, but the first step towards this result must be the knowledge of their constitution, to be followed by a series of careful experiments.

Citric acid is a powerful tribasic acid (see ACIDS), and the solution in water readily dissolves zinc and iron. It forms a class of salts called Citrates, many of which are employed in medicine.

The so-called *Citrate of Magnesia*, a granular substance, which effervesces on the addition of water, and is very popular as a gentle aperient, is not really a citrate at all, but consists of a mixture of tartaric and citric acids, bicarbonate of soda, and sugar, with perhaps a trace of some magnesium salt to justify the name. The granulating is effected by mixing the powders and placing them in a pan heated by steam, when, in proportion to the citric acid present, the powders run together into a pasty mass. This is forced through a coarse riddle, and the granules are dried by a gentle heat.

Citrate of Potash, $K_3C_6H_5O_7,H_2O$, is prepared by neutralising citric acid with bicarbonate of soda. It forms a white, granular, deliquescent powder, which acts as a cooling diaphoretic in cases of fever. Dissolved in lemon-juice it is of much value in rheumatism. It is given in doses of 20 to 30 grains.

Citrate of Ammonia can only be obtained in solution, as when this is evaporated decomposition takes place and ammonia escapes. It is employed, like the potash salt, in febrile diseases.

Citrate of Iron and *Citrate of Iron and Quinine* are but examples of a large number of compounds obtained in the form of brown or greenish-brown scales which are largely used in medicine. In these the medicinal value lies not in the citric acid, but in the iron or quinine with which it is associated, although the acid has doubtless a subsidiary action. A peculiarity about these 'scale preparations,' as they are called, is that the inky taste, so characteristic of iron in the form of steel drops, is in great measure removed. Citric acid also forms a series of organic salts called citric ethers, of which citrate of ethyl is an example. Lemon-juice, in which citric acid is the most active ingredient, is a most valuable medicine in scurvy, and when it cannot be obtained the acid may be used as a substitute. Citric acid in solution does not, however, appear to be nearly so effective as the juice itself.

Clarification is the process of clearing a fluid from a turbid condition, as in the case of Beer (q.v.), or in the action of gelatin in fining British wines. Natural waters containing much organic matter in mechanical suspension and in chemical solution are clarified by the addition of a little alum, which is precipitated with the organic matter, and the water then becomes healthy and refreshing. Liquids are often clarified by straining through several layers of cloth, or through sand or charcoal. The use of the Clearing Nut (q.v.) for clarifying water is general in India. A very interesting and useful method of clarification is that in which a 'centrifugal' is employed. This consists of a circular vessel provided with an outlet in the centre and also at the circumference, and which is so constructed as to be capable of being made to revolve at a very high speed. When the muddy liquid is placed in the vessel, and the whole caused to revolve, it is found that the particles of dust, mud, or other matter fly to the circumference, leaving the liquid in the centre practically clear. By suitable arrangements the clear liquid can be drawn off.

Coagulation, the amorphous (q.v.) solidification of a liquid, or part of a liquid, as when the casein of milk is solidified by rennet in making Cheese (q.v.), or the white of an egg by boiling. The process varies in various substances. Albumen, or the white of an egg, coagulates at a temperature of 160°. Milk is coagulated or curdled by the action of rennet or by acids. The fibrin in the blood, chyle, and lymph of animals is coagulated by the separation of these fluids from the living body.

Coal-tar, or GAS-TAR, is a thick, black, opaque liquid, which comes over and condenses in the pipes when coal or petroleum is distilled. Now usually obtained in the manufacture of gas, tar was about 1782 extracted from coal by the ninth Earl of Dundonald under a patent, expressly for the purpose of being used for protecting ships from rotting. Coal-tar is slightly heavier than water, and has a strong, disagreeable odour. The amount of tar so obtained of course varies with the nature of the coal employed, but it is also dependent on the average temperature of distillation. With a low temperature, a large quantity of tar is produced, along with a small yield of a highly illuminating gas. At first this tar was regarded as a waste product, or, at most, as a source of pitch; but it soon became apparent that as a source of Benzene (q.v.), and through it of the Aniline Dyes (q.v.), it was a commodity of great commercial value.

When coal-tar is distilled, a large number of volatile substances pass over as the temperature rises higher and higher. At first various gases, ammonia and naphtha, are obtained to the extent of about $\frac{1}{20}$th part of the original tar, and then distillation ceases, although the temperature gradually rises. After a period of about an hour, more oils, like the former, lighter than water, are obtained, and so on the distillation proceeds, with successive intervals, yielding what are known as Creosote oils, and finally Anthracene oils, the residue in the still being pitch.

At first, when anthracene was of little importance, distillation was not pushed so far, and the anthracene oils were allowed to remain in the pitch; but since the discovery of the process for making artificial Alizarin (q.v.), the heat is pushed as far as possible consistent with the production of a pitch that will sell. The first light oils yield chiefly benzol, carbolic acid, and naphtha. The creosote oils yield creosote and naphthaline, while the anthracene oils produce anthracene and lubricating oils.

After this enumeration of the chief coal-tar products, it will be possible to realise the great importance of this substance. The naphtha, besides being used as a solvent for india-rubber and gutta-percha, is burned to produce a fine variety of carbon for printing-ink. The benzol, including in this term many nearly allied substances, not only yields many brilliant dyes, but is used for cleaning gloves, silks, &c., and other articles which would be injured by washing. The creosote in its crude form is largely used for preserving wood, enabling it to be exposed in damp situations without rotting, while, when burned, its smoke yields lampblack. The naphthaline, besides being a source of many dyes, is employed in the Albo-carbon light to give to ordinary coal-gas very high illuminating power. Finally, the residual pitch is in constant requisition for making roofing felt and asphalt pavement. Besides these primary products of coal-tar, there are of course numerous compounds derived more or less remotely from it. Such are the aniline dyes, the quinine substitutes, antipyrin, antifebrin, &c., and the sweetening substance, Saccharine (q.v.), which may be used to replace sugar in many cases.

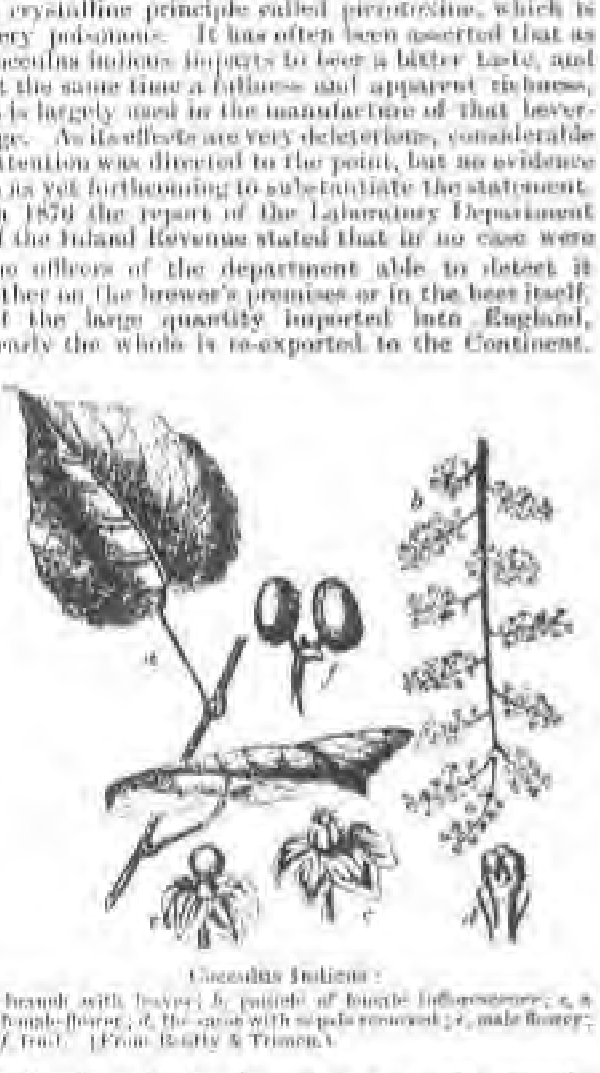
Co'ca (*Erythroxylon Coca*—which has of course no connection with Cocoa or with Cocoa-nuts), a shrub of the order Erythroxylaceæ, of which the leaves furnish an important narcotic and stimulant. The shrub is 6 or 8 feet high, and somewhat resembles a blackthorn bush; the leaves are ovate-lanceolate, simple, and with entire and slightly waved margins, and strongly marked veins, of which two on each side of the midrib run parallel to the margin. It has been in use from a very remote period among the Indians of South America, and was extensively cultivated before the Spanish conquest. Many of the Indians of the Peruvian Andes are to this day excessively addicted to it, and its use is quite general among them, besides extending to men of European race. The dried leaves are chewed with a little finely powdered unslaked lime, or with the alkaline ashes of the Quinoa (q.v.), or certain other plants. An infusion is also occasionally used. An habitual coca-chewer takes a dose about four times daily. In soothing effect it recalls tobacco, but its influence is a much more remarkable one. It greatly lessens the desire for ordinary food, and at the same time permits of much more sustained exertion, even without sleep; it affects the nervous mechanism of respiration, so that the difficulty of breathing, so common in the ascent of long and steep slopes at high elevations, is little felt. These properties readily explain its high esteem among

Coca (*Erythroxylon Coca*):
a, flower; *b*, fruit.

the Indians, to whom long and difficult journeys, heavy burdens, and constant privation have always been familiar.

COCAINE.—In Europe, little importance was attached to coca until the veteran pharmacologist Christison awakened interest by personally verifying in old age its sustaining powers. Investigations followed, and the alkaloid *cocaine*, upon which the active properties mainly depend, has now come into regular use as a local anæsthetic, by help of which not merely some of the operations of dentistry, but much more serious surgical operations, can be performed without chloroform. To oculists it is of special value, at once dilating the pupil and removing all sensibility. Cases of intoxication and abuse are not infrequent with the leaves, and have been already recorded in connection with the more powerful extract.

Coc'culus In'dicus (Ital. *coccola*, 'a berry') is the fruit of the *Anamirta paniculata*, a climbing shrub found in the eastern parts of India, and in the Malayan Archipelago. It was introduced into Britain in the 16th century for the purpose of stupefying fish so that they might be caught by hand. It acts as an acrid narcotic poison, and when the berries are thrown into a stream it quickly poisons any fish in the neighbourhood. It contains a crystalline principle called picrotoxine, which is very poisonous. It has often been asserted that as cocculus indicus imparts to beer a bitter taste, and at the same time a fulness and apparent richness, it is largely used in the manufacture of that beverage. As its effects are very deleterious, considerable attention was directed to the point, but no evidence is as yet forthcoming to substantiate the statement. In 1879 the report of the Laboratory Department of the Inland Revenue stated that in no case were the officers of the department able to detect it either on the brewer's premises or in the beer itself. Of the large quantity imported into England, nearly the whole is re-exported to the Continent.



Cocculus Indicus:
a, branch with leaves; *b*, panicle of female inflorescence; *c*, a female flower; *d*, the same with sepals removed; *e*, male flower; *f*, fruit. (From Bentley & Trimen.)

In Russia and elsewhere it is a popular remedy for tapeworm, lice, &c.; but when applied to the scalp it is not unattended with danger, as several deaths have occurred from its use.

Cochineal, a dyestuff employed in dyeing scarlet and crimson, and in the preparation of the pigments Carmine and Lake (q.v.).

Cochineal consists simply of the bodies of the females of a species of Coccus (q.v.), called *C. cacti*, because it feeds upon plants of the Cactus family, particularly on one, therefore designated the cochineal plant, but known in Mexico as the Nopal (*Opuntia coccinellifera*), figured in the article CACTEÆ. This plant is nearly allied to the prickly pear, and assumes a somewhat tree-like form. The insect as well as the cactus are natives of Mexico and other warm parts of America, but they are now cultivated chiefly in Guatemala. This cultivation was carried on by the Mexicans long before the country was known to Europeans. The insect is not uncommon on wild cacti in Texas and Florida. Both plant and insect have been successfully introduced into the Canary Islands, Algeria,

Cochineal (*Coccus cacti*):
a, living on cactus (*Opuntia*); *b*, male; *c*, female.

Java, and Australia. But the attempt to produce cochineal in India has been practically a failure.

The cochineal insect is a small creature, a pound of cochineal being calculated to contain 70,000 in a dried state. The male is of a deep-red colour, and has white wings. The female, which is wingless, is of a deep-brown colour, covered with a white waxy powder; flat beneath, convex above.

In some parts of Guatemala large plantations of Nopal exist for the cultivation of the *C. cacti*. Before the rainy season commences, branches of this cactus plant covered with these insects are cut off and stored in buildings to protect them from the weather. When the wet season is over, four or five months afterwards (October), the plantations are again stocked from these supplies. Little 'nests' of some vegetable fibre, each containing about a dozen females, are placed on the spines of the cacti. The eggs are soon deposited, and when the young females are developed, they spread over the plants, attaching themselves to the leaves, and looking more like vegetable excrescences than insects. They become covered with a cottony substance. The first crop of pregnant females, only these being valuable for cochineal, is gathered in December, and several more crops are obtained till the following May.

In the Canary Islands the insects are reared in winter and put out on the cactus leaves from May to July. Small gauze bags containing pregnant females are hung on the cactus plants, from which the young when developed spread over the leaves. In August and September, just before the females are ready to deposit their eggs, they are collected in trays, and those gathered in one day are placed in the evening in an oven heated to 150° F. They are afterwards more thoroughly dried in the sun. Hot iron and boiling water are also used in killing the insects. According to the way the insect is killed and dried, the cochineal is known in commerce as silver or black; an inferior kind being sometimes called foxy. The colouring principle of cochineal is called cochinealin or carminic acid, and the insects scarcely yield more than 10 per cent. of pure dye, although the amount is generally supposed to be much greater. Carmine has also been demonstrated in other kinds of coccus and in aphides.

The cochineal industry has suffered very much through the introduction of aniline dyes.

Codeine, an alkaloid obtained from poppy-heads. See POPPY.

Cod-liver Oil is generally obtained from the livers of the common Cod (q.v.), but likewise from allied species, as ling, dorse, coal-fish, torsk, &c. In these fish the Adipose Tissue (q.v.) containing oil is almost entirely confined to the liver, in which they agree with the shark tribe, whilst in other fish, as in the herring and salmon, the oil is diffused over the entire structure of the animal. The supplies of medicinal cod-liver oil used to be derived mainly from Newfoundland, but Norway now supplies the bulk of that used in Great Britain. The most famous of the Norwegian fishing-grounds is that of the Lofoden Islands. On the outer shores of these islands immense shoals of fish begin to arrive in December, but owing to the storms to which the coasts are liable, only a comparatively small number of boats (some 800) engage in the fishing. Later on, in the beginning of January, the fish pass in between the islands and enter the calmer waters of the Westfjord to spawn. Then the fishermen, assembling in immense numbers, catch the fish by net or baited line. A good catch for a boat, with a crew of five men and a boy, is from 600 to 1200 fish; and some idea of the importance of this industry is obtained from the fact that in a single year these fisheries alone employed 4000 vessels, with a crew of 27,000 men, the catch amounting to 25,000,000 of fish. The fishing-grounds being near the shore, the fish are at once cleaned, and the livers removed. These may be treated in different ways, the various qualities of cod-liver oil being the result. The finest oil, known as 'non-freezing pale oil,' is obtained by warming the livers by means of steam heat, when the oil separates, and is either removed by straining or by allowing it to float to the surface. It is then cooled to 14° (– 10° C.), and filtered, either by mechanical pressure or in the usual way. A white tallow-like substance remains in the flannel filter, and a bright cod-liver oil passes through, which is now capable of being exposed to frost without turning turbid.

In the case of those fisheries which are situated at some distance from the shore, the livers are placed in tanks, till a sufficient quantity has been collected, with the result that partial putrefaction takes place. The oil obtained in this way is of a dark-brown colour, and possesses a nauseous empyreumatic taste.

A still coarser variety is manufactured for use in leather-making. In it the livers of the cod, herring, haddock, &c. are indiscriminately used, a very fishy-tasted oil being the result.

It will be seen from the above that the different varieties of cod-liver oil may be produced from the same livers. Thus, that obtained by pressure or steam heat from fresh livers is the finest from taste and colour, while the oil becomes darker and darker as the livers become less fresh. It has been supposed by some authorities that the dark-brown oil is the more efficacious, but others find no difference in actual practice, while the pale oil can alone be tolerated by delicate stomachs. Cod-liver oil mainly consists of oleic, stearic, and palmitic acids, in combination with glycerine. In addition to these, *gaduin*, a substance of biliary origin, but possessing no recognised medicinal virtues, is present along with iodine and bromine. Some have ascribed the virtues of cod-liver oil to the iodine or bromine, but as the iodine is only present in the proportion of 1 part in 2000 parts of the oil, this view seems untenable. Sometimes the oil is adulterated with spurious oils, to which iodine has been added, and this may be assumed if the proportion of iodine exceeds that stated above. There are unfortunately no chemical tests that can with certainty detect the presence of other oils, although there are tests which distinguish liver-oils from those of other origin. Thus with nitric acid, cod-liver oil yields a purple colour, changing to a brown; while a drop of sulphuric acid produces a violet colour, soon changing to brownish red. In order to prevent it from becoming rancid and fishy-tasted, it is well to keep it secluded from the air.

Cod-liver oil is at present one of the most important remedies in the Materia Medica. Although possessing a high reputation on the Continent, it was not till 1841, when Professor Hughes Bennett (q.v.) of Edinburgh wrote a treatise on it, that it came into general use in Britain. It is most valued in cases of pulmonary consumption, chronic rheumatism, and gout, besides all diseases of a scrofulous nature. In all these it is, however, useless to expect good results unless the remedy has been regularly taken for several weeks. Its mode of action is uncertain. While some hold that it merely acts as a nutrient, it is certain that pork-fat, butter, and other digestible oils, do not have the same specific action that characterises cod-liver oil. It is given in doses of from half a teaspoonful to one tablespoonful three or four times a day, and it does not seem that excessive doses, such as a cupful or more, are of any real benefit, while they are a severe strain on the digestive organs.

As its peculiar flavour is very repulsive to many patients, various devices have been adopted to render it more palatable. The addition of a trace of sulphuric ether, while rendering it more easily digested, does not improve the flavour. It may, however, be made into a jelly with isinglass, or be taken floating on the surface of porter; while in the form of *Emulsion*, of which many varieties are in the market, the flavour is more or less skilfully disguised. Most druggists also keep gelatin capsules, containing from one to one and a half teaspoonful, which are easily swallowed.

Cohesion depends upon the molecular forces which keep together the parts of bodies, and are insensible at sensible distances. In the case of a small body these forces are much more efficient in keeping the parts together than are the mutual gravitational attractions of the parts. On the other hand, in the case of a large body, such as the earth, gravitation is much more powerful in preventing rupture than cohesion. The term *adhesion* is generally, though quite unnecessarily, used when the cohering particles are dissimilar—as when water clings to glass.

After the parts of a body have been separated, so as to form an incoherent mass, the force of cohesion may be again brought into action by the application of pressure sufficient to force the particles close enough together. Thus two smooth, freshly cut pieces of lead can be made to adhere by slight pressure accompanied by a screwing motion. Also two very smooth slabs of marble adhere, if pressed together, so that considerable force must be exerted to separate them. Barton made a set of cubes with surfaces so true that, if twelve of them were piled one over the other, the whole series could be lifted by raising the upper one. Lead pencils are made by applying pressure to powdered graphite, so as to make it cohere.

Coke is a form of fuel obtained by the heating of coal in confined spaces whereby its more volatile constituents are driven off. Caking coal is the most suitable for the manufacture of coke, which, in its principal qualities, is approached by the hard anthracitic coals. The process of coking is conducted (1) in heaps or mounds, or (2) in ovens; but coke is also produced in gas retorts, where, however, it is merely a secondary product. Coking in mounds—a method now little practised—is done in a way similar to that employed for preparing charcoal from wood. The coal is built up into round stacks, around a wide open chimney or column, the larger masses being placed in the centre, and small broken coal outside, the whole being covered with wet coke-dust, except at certain air-holes. The mound of coal is ignited from above, and burns gradually downwards and outwards, giving off at first much smoke and vapour, which consist mainly of tar-water and coal-gas. When the fire ceases to be smoky, the process of coking is concluded, all openings are covered over to exclude air and extinguish combustion, and cooling of the mound is aided by drenching it with water. The principle of making coke in coke-ovens is the same, but the process is much quicker and more economical, and the resulting coke is better in quality than that made in mounds. Formerly the heat and volatile gases given off in coking were allowed freely to escape, but in modern coke-ovens arrangements are made for utilising the combustion in one retort to force the heat of another, by passing the hot gases in flues around contiguous ovens. The whole of the gases pass from these flues into a common flue, by which they are carried away to heat steam-boilers. In a similar way the coal-gas is, from certain kinds of ovens, collected and burned, and the tar-water evolved is condensed and used as a source of ammonia and gas-tar products.

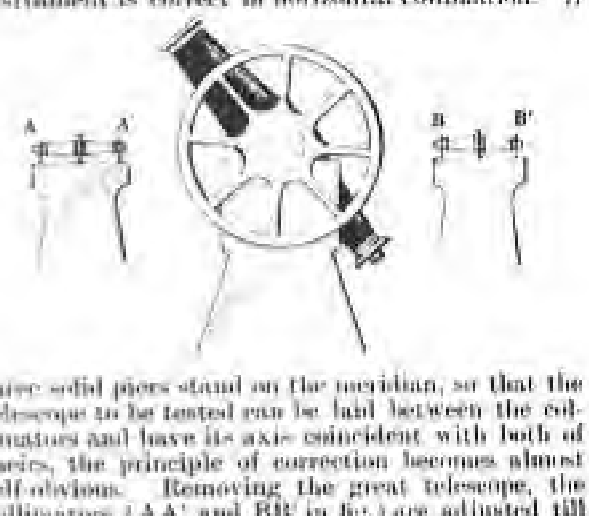
Coke is a hard, brittle, porous solid, with a steel-gray, somewhat metallic lustre, and it does not soil the fingers when being handled. It is principally valued for the intense heat which it gives off in combustion, for its freedom from smoke in burning, and because it does not become pasty and adhesive in the fire. The process of coking also drives off a good deal of the sulphur which may be present in coal, and all these properties render coke a most valuable fuel for many metallurgical operations, and for use where intense smokeless combustion is a desideratum. The higher the temperature to which coal in coking is submitted, the harder and more valuable is the resulting coke, and the heat it gives off is relatively more intense. In chemical constitution coke consists of a modified form of graphite contaminated with earthy impurities from the ash present in coal. Coal yields by weight about 70 per cent. of coke, which, however, increases in volume in the process of coking by about one-fourth. Coke will absorb about 30 per cent. of moisture from the air, a circumstance which should be borne in mind in its purchase and its use, for such moisture in being driven off greatly reduces the calorific value of the substance.

Colcothar is the name given by the alchemists to the red powder (mainly red oxide of iron) which remains in the retorts when green vitriol or the sulphate of iron is calcined. It is used for polishing glass and the like, and is called crocus by artists.

Cold Cream is the term applied to an ointment containing rose-water which is used as a mild and cooling dressing for the skin. It may be prepared by melting together almond-oil five parts, spermaceti one part, and white wax one part. Three parts of rose-water are then added with brisk stirring, which is continued till the whole is cool, and of a soft creamy consistence. As cold cream prepared in this way is liable to turn rancid, glycerine is sometimes added, or the almond-oil is replaced by white vaseline. Cold cream is a pleasant application to irritated surfaces, protecting them from the influences of the weather, and promoting the healing of wounds and chapped hands.

Colic (Gr. *colon*, 'the large intestine;' see INTESTINES), a name employed by the later Greek and the Roman physicians to denote diseases attended with severe pain and flatulent distension of the abdomen, without diarrhœa or looseness of the bowels. The disease (commonly called *gripes* or *belly-ache*) is now generally believed to be spasmodic in character, and to be dependent upon irregular contractions of the muscular coat of the intestines; its supposed particular connection with the colon, or large intestine, however, is not usually to be made out from the symptoms. Painful disorders of the bowels are very frequent in persons who are not attentive to the regular evacuations, especially when they are exposed to cold so as to experience chill or coldness of the feet, which will often suffice to bring on an attack of colic. The disease is usually attended with Constipation (q.v.), and ceases when the regular action of the bowels is restored, although often in this case the operation of medicine is attended by continued pain for a time. Warm fomentations to the abdomen may be employed with advantage, sometimes medicated with opium, or decoction of poppy-heads; and great relief is commonly experienced from friction with a warm liniment, such as opodeldoc, or the soap and opium liniment. Pressure with the hand over the painful part commonly diminishes the suffering for the time in simple colic, but increases it in more serious diseases. Warmth to the feet, and the recumbent posture, are also to be recommended. In very severe or protracted cases opium may be taken internally. A good remedy in such cases is a full dose of castor-oil (one ounce or more for an adult), with 30 or 35 drops of laudanum, or of solution of morphia. (Opiates should not be given to children except under medical advice, and in very reduced doses.) When colic resists such mild and simple remedies as the above—when it is accompanied by tenderness of the belly, or by hard swelling in any part of it—when constipation is obstinate, or vomiting is present—when there is feverishness, or tendency to exhaustion—or when there is reason to believe that it may depend on any other cause than the mere accumulation of the products of digestion in the intestines, no time should be lost in seeking the best medical assistance that can be procured; for colic is closely allied as a symptom to several very severe and dangerous diseases. One of these complicated forms of colic is termed Ileus, or Iliac passion (from the idea that its seat was in the small intestine—*ileum*). It is attended with obstruction of the bowels, often from mechanical twisting or involution of one part with another (hence termed *volvulus*). This is, of course, a disease of extreme danger. The only treatment that can be attempted without medical assistance is the employment of large injections by the lower bowel, and opium in moderate and repeated doses ($\frac{1}{2}$ grain to 1 grain, or 12 to 20 drops of laudanum) by the mouth, carefully watched, and discontinued if there is any sign of narcotism (see OPIUM). Colic pains are also present in Peritonitis (q.v.), another most dangerous form of disease; and they form one marked symptom of the slow poisoning by lead, occasionally observed as the consequence of contamination of drinking water by leaden cisterns, &c. In this form, the treatment is different from that of simple colic, and will be treated of under LEAD-POISONING.

Collimator, a subsidiary telescope used to detect or correct errors in collimation (i.e. in directing the sight to a fixed object) when adjusting for transit observations. When the vertical thread in the field of view exactly coincides with the vertical axis of a telescope, the instrument is *collimated* vertically; and when the horizontal spider's thread just covers the horizontal axis, the instrument is correct in horizontal collimation. If



three solid piers stand on the meridian, so that the telescope to be tested can be laid between the collimators and have its axis coincident with both of theirs, the principle of correction becomes almost self-obvious. Removing the great telescope, the collimators (AA' and BB' in fig.) are adjusted till the cross-wires in one coincide perfectly with those of the other in all possible positions. Then replacing the 'transit circle,' it is examined and tested by reference, first to one, and then the other collimator, the verification requiring that it be turned through 180° till the threads in the three fields of view absolutely coincide, and the collimation is pronounced perfect.

Practical astronomers set great value on the collimator (in the arrangement just described) for having entirely superseded the 'meridian mark.' By Rittenhouse's principle a telescope can become its own collimator, especially in determining the nadir point. When the axis is vertical over a vessel containing mercury, the telescope will be collimated when the cross-wires are brought to exact coincidence with their image seen in the mercury.

Collodion (Gr. *kolla*, 'I stick') is a solution of Gun-cotton (q.v.) or pyroxylin. Cotton itself is not soluble in alcohol or ether, but when treated, either in the form of cotton-wool, rags, or paper, with a mixture of five parts of strong nitric acid, and six of sulphuric acid, it is found that it can now be dissolved in ether, or in a mixture of ether and alcohol. To this modification the name pyroxylin is applied. There are many varieties of collodion divisible into surgical or medicated collodions, and photographic collodions. When one part of pyroxylin is dissolved in thirty-six parts of ether and twelve parts of alcohol, a thickish liquid is obtained, which evaporates rapidly, leaving a thin film of pyroxylin. As an application to wounds, where it is desired to keep the edges close together, this form of collodion is of use, owing to the contractility of the pyroxylin film which it leaves, but for general purposes a flexile or flexible collodion, as it is called, is desirable. This is produced by the addition of a little Canada balsam and castor-oil to the ordinary variety. Flexile collodion is largely used as a covering for abraded surfaces, as a remedy for burns, for sore nipples, &c., and it is also the basis for many medicated collodions, such as styptic collodion, cantharidal or blistering collodion, &c. Salicylated collodion is well known as a popular corn cure, and it is certainly most effectual in removing hard or soft corns with but slight inconvenience. It contains, in addition to salicylic acid, the active principle, a little extract of Indian hemp, which prevents the slight pain, which might otherwise prove troublesome. Collodion plays a very important part in Photography (q.v.).

Colloid is a name applied by Graham to any soluble substance which, when exposed to *Dialysis* (q.v.), does not pass through the porous membrane. Starch, gum, albumen, and gelatin are examples of colloids; and the name is used in contradistinction to *crystalloids*.

Coma, a Greek word used in medicine, to signify a state of more or less profound insensibility allied to sleep, but differing from natural sleep in its characters as well as in the circumstances under which it occurs. In coma the patient lies on his back, and is either simply insensible to external impressions, or has a confused and dull perception of them, with restlessness and low Delirium (q.v.). The former kind of coma occurs in apoplexy and epilepsy, and also in many other organic diseases of the brain and its membranes, of which, indeed, it may be said to be the natural termination. It is also seen in narcotic poisoning, and most characteristically in poisoning by Opium (q.v.). In the most fatal forms, the breathing is very slow and noisy (snoring or stertorous), accompanied with puffing of the cheeks; the pulse is at first strong and regular, afterwards feeble; there is often lividity; and the pupils are either contracted or excessively dilated, but in either case immovable, and totally insensible to light. In the second variety of coma, there is perpetual restless delirium, without enough of sensibility to lead to spontaneous and regular voluntary movements; the patient mutters slightly, and grasps feebly and without purpose at any object in his way; the pupils are commonly contracted, and the tongue is apt to be dry and brown. This kind of coma is mainly seen in many fevers, and forms one of the modes of their fatal termination. The treatment of coma is that of the disease or accident leading to it. Where there is a reasonable chance of recovery, the patient must be roused to consciousness as much as possible, either by frequent movements or strong impressions on the skin, or by the use of galvanism, so as to maintain the respiration (see OPIUM). Blistering of the head is also sometimes resorted to with good effect.

Combustion is the term commonly applied to those chemical processes which are accompanied in a marked degree by the production of heat and light. The most familiar of such processes are those in which oxygen of the atmosphere combines chemically with the constituents of what are ordinarily spoken of as combustible substances, such as wood, coal, fats, oils, &c. Chemical combination is, as a rule, accompanied by the evolution of heat and frequently of light (see CHEMISTRY); but every case of chemical combination is not called combustion, because in many cases the quantity of heat evolved is inconsiderable.

When we speak of the combustion of, for instance, coal or wood, we mean the chemical process which consists, in general terms, in the combination of the oxygen of the air with the carbon and hydrogen which constitute the greater part of the combustible portion of either of these substances, and in the production of carbonic acid and water. Many instances are known to chemists in which the oxygen required for a combustion is not derived directly from the atmosphere, but from some oxidising (or oxygen-yielding) agent, and frequently the place of the oxygen may be altogether taken by some other element, as, for instance, when metals, such as antimony in powder, burn in chlorine.

The combustion of every combustible substance is accompanied by the evolution of a quite definite quantity of heat, which is invariable for each substance, whether the combustion takes place rapidly or slowly. A piece of phosphorus, for instance, as is well known, glows in the dark. This is a process of very slow combustion, and is never accompanied by much rise of temperature. When moderately heated in air, a piece of phosphorus bursts into flame, and the combustion is rapid and is accompanied by a considerable rise of temperature; whilst if the phosphorus be burned in pure oxygen, the combustion is an extremely brilliant spectacle, and a high temperature is attained. In each case the actual quantity of heat given out is identical for the same weight of phosphorus, but the time occupied by the combustion varies, and consequently the temperature at any given instant must also vary.

The quantities of heat given out by the combustion of the same weights of *different* substances vary greatly. The measurement of quantities of heat produced by combustion and in other ways is called calorimetry (see HEAT).

The name combustion is applied to a particular process in the analysis of organic compounds. See ANALYSIS (ORGANIC). See also SPONTANEOUS COMBUSTION.

Comfrey (*Symphytum*), a common palearctic genus of Boraginaceæ, somewhat coarse perennial herbs, although occasionally to be seen in flower-borders. *S. officinale* (blue) and *S. tuberosum* (yellow) are frequent in shady and moist places. *S. officinale* was formerly much esteemed as a vulnerary. Its young leaves and its blanched shoots are still occasionally used as boiled vegetables. The Prickly Comfrey (*S. asperrimum*), a native of Siberia, 6-10 feet in height, has been recommended for feeding cattle. The stamens are covered in this genus by five awl-shaped processes pushed in from the outside of the corolla, and meeting so as to form a false bottom impassable to ants, flies, and other small honey-thieves, but which can be thrust aside by the

Comfrey (*Symphytum officinale*).

humble-bees which alone fertilise the flower. Many bees, however (especially *B. terrestris* and one or two others), prefer to bite a hole in the side of the corolla below this cover, and the flowers may thus be seen to be visited both in the legitimate and illegitimate way.

Compass, MARINER'S, is a magnetic instrument used by mariners to indicate the direction of the ship with respect to the magnetic north and south line, or, in other words, to give the azimuth of the ship with respect to the magnetic meridian. That the mariner may know his direction with respect to the geographical meridian, he must know the angle between the magnetic and geographical meridians (see DECLINATION), and as this angle is different in different years and at different places on the surface of the globe, the mariner must be able at any time to determine his position, when his charts will give him the necessary data to supplement his compass reading.

The directive property of the magnet seems to have been unknown in Europe till the 12th century. It appears, however, on very good authority that it was known in China and throughout the East generally at a very remote period. The Chinese annals assign its discovery to the year 2634 B.C., when they say an instrument for indicating the south was constructed by the Emperor Hoang-ti. The earliest reference to the making of magnets is in a Chinese dictionary of 121 A.D., where lodestone is defined as 'a stone with which an attraction can be given to the needle;' but this property of the lodestone could not fail to have been observed at a very much earlier time. At first the Chinese would appear to have used the compass exclusively for guidance in travelling by land, and we hear of their using it by sea only somewhere about 300 A.D. According to one account, a knowledge of the compass was brought to Europe by Marco Polo on his return from his travels in Cathay; but as against this, the late Mr William Chappell, in a letter to *Nature* (June 15, 1876), produced evidence to show that we owe the appearance of the compass in Europe in the 12th century to independent discovery, and not to importation from China.

Fig. 1.

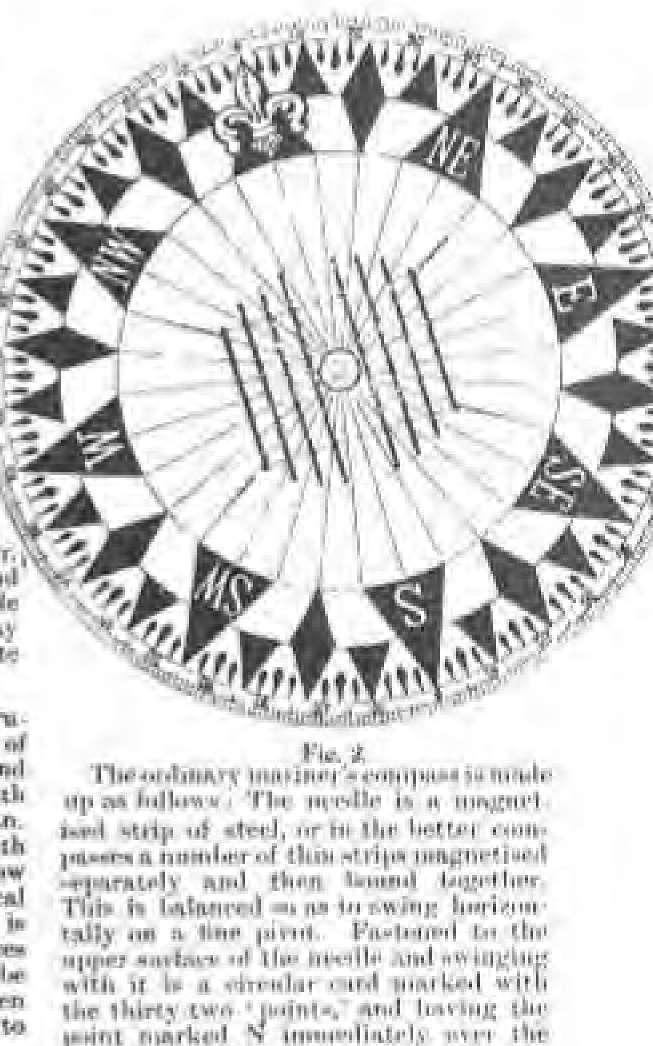


Fig. 2.

The ordinary mariner's compass is made up as follows: The needle is a magnetised strip of steel, or in the better compasses a number of thin strips magnetised separately and then bound together. This is balanced so as to swing horizontally on a fine pivot. Fastened to the upper surface of the needle and swinging with it is a circular card marked with the thirty-two 'points,' and having the point marked N immediately over the end of the needle that is attracted to the north. The pivot on which the needle swings stands up from the bottom of a copper bowl, which has a glass covering to protect the contents from wind and weather. The compass bowl is made of copper (a good conductor of electricity) in order to damp the vibrations of the needle. For the needle in moving induces currents of electricity in the copper bowl, the electro-magnetic forces of which tend (according to Lenz's Law) to oppose the motion producing them. For the same purpose also the compass-bowl is sometimes filled with spirit, but the additional friction of the liquid interferes with the sensitiveness of the needle. The bowl is supported in Gimbals (q.v.) so as to remain horizontal in all positions of the ship. The whole arrangement is placed in the binnacle, situated when possible in the fore and aft line, and having provision for the placing of lamps to illuminate the compass-card by night.

The compass-card is represented in fig. 1. The four *cardinal* directions or 'points' are marked N, E, S, W., and there is a convenient notation for intermediate points. Thus the point midway between N. and E. is called NE., that again between N. and NE. is called NNE. (read north-north-east), and so on. The remaining sixteen points, such as

N$\frac{1}{4}$E. (read north by east), are named on a plan which will be readily made out by an examination of the figure. These thirty-two points are often further subdivided into halves, quarters, and even eighths, and then we have N$\frac{1}{4}$E., and so on. When the ship lies in the magnetic meridian, and points to the north, the N. point on the card is directed towards a black line, called the lubber's line, marked on the inside of the compass-bowl. Boxing the compass means reading off from memory the thirty-two points in order going round either way.

Modified forms of the compass are in use on land by surveyors and miners, and need not be further alluded to here.

By way of summarising the qualifications of a good compass, we shall describe the best compass in use—Sir William Thomson's, patented in 1876: A thin aluminium ring (fig. 2) is connected by silk threads with an aluminium boss, which rests on an aluminium cup having a centre piece of sapphire poised on an iridium point (fig. 3). Instead of a single needle there are eight thin strips of steel fastened to the silk threads as shown in the figure. The thin paper rim bearing the points is divided at intervals so that the contractions and expansions due to change of temperature may not produce warping of the aluminium. The whole arrangement weighs only 200 grains or so, and thus there is very little tendency to flatten the point of the supporting needle. Hence the 'friction error' can be made very small—in fact, if it is found that a card can be made to rest even half a degree out of the magnetic meridian, the supporting point is rejected for a sharper one. The weight, such as it is, being mostly in the rim, the period of vibration of the card is long (40 seconds, or so), which makes the card very steady. The bowl is saved from violent oscillation by having in the bottom a quantity of castor-oil. The gimbals are supported on knife edges, and their being made of brass-wire rope dispenses with the not very durable india-rubber pads otherwise used. A simple device prevents the card from jumping off the pivot when heavy guns are fired—a matter of some importance in an engagement. The binnacle has complete provision for stowing away the magnets, soft iron bars, and spheres used to counteract the magnetism of the iron of the ship.

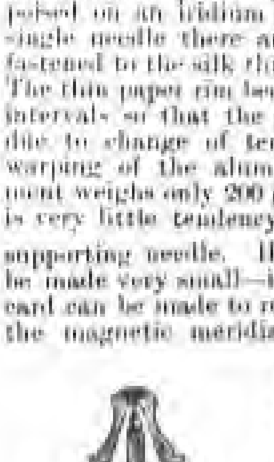


Fig. 3

Along with Thomson's compass is supplied a piece of apparatus for converting it into an azimuth compass, which is a compass for finding the angle subtended at the observer's eye by the projections of two objects on the horizontal plane.

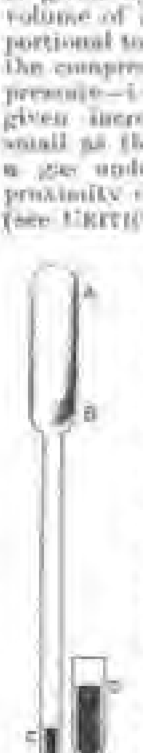
For the earth's action on a magnetised needle suspended free to move horizontally and vertically, see the articles MAGNETISM, DECLINATION.

The great difficulty connected with the use of the compass arises from the disturbing influence of the ship's magnetism, of which part is considered permanent, and part—due to the soft iron—is temporary, and varies with the position of the ship. Various methods are in use to regulate this difficulty, which in iron vessels is sometimes so great as to make an ordinary compass almost useless. The principal are (1) counteracting the permanent induced magnetism by properly placed permanent bar magnets; and (2) supplying about the compass soft iron masses in such a way that, however the ship turns, the transient induced magnetism on the left of the compass shall be exactly equivalent to that on the right. Many of the best ships carry a standard compass placed as far as possible from the iron of the ship, especially from vertical masses like iron masts and funnels. When it is mentioned that an error of one point (11$\frac{1}{4}$°) in steering means an error of about one mile in five, the necessity for the various precautions will be readily recognised. For details on this subject, see the *Admiralty Manual on the Deviations of the Compass*, and the references there given.

Compressed-air Motors. One mode of employing air as a motive power has been described under AIR-ENGINE (q.v.). Another obvious way is to compress the air and then apply it in the manner of high-pressure steam. But the great loss of power, due principally to the dissipation of the heat which results from the high compression of the air, will always render the employment of such a motive power very wasteful. There are, however, many conditions under which the use of compressed air is convenient and advantageous. The air-gun, although more a toy than a useful weapon, is one of the oldest examples of a compressed-air motor. Partly by compression and partly by exhaustion of air, pneumatic tubes are worked in connection with central post-offices for the transmission of letters and messages to and from various districts in large cities. In boring in mines, and in blasting and tunnelling operations, compressed air is an exceedingly useful agent, the power being easily carried by tubes into confined areas where the air when liberated, after it performs its primary duty, is of great value for aiding the ventilation of the spaces. In the application of automatic brakes to passenger trains, compressed air has also been found to be the most convenient power. Air compressed and stored in a reservoir under the vehicle has also been proposed as a motive power for tramway cars. In a different direction the agency of compressed air is important in the artificial production of cold for chilling houses for meat preservation on land, and for frozen-meat chambers for preserving fresh meat on board vessels.

Compression and **Compressibility.** When a body is subjected to the action of any force which causes it to occupy less volume, it is said to be compressed, and the diminution of volume is termed *compression*. The term compressibility is frequently used to signify that property of bodies whereby they yield to that particular form of stress known as pressure; but more strictly it is employed to denote the measure of this property as possessed by different substances. Under the same pressure it is obvious that the same volume of various substances will diminish by different amounts; and, to measure this change, *the compressibility* is defined to be the ratio of the amount of compression per unit volume to the compressing force applied. It thus may be determined by measuring the amount of compression of a known volume when under a certain pressure; dividing this by the product of the original volume and the pressure gives the average compressibility (per unit pressure) of the substance throughout the range of pressure employed. The unit of pressure generally used is *one atmosphere*, which is defined in this country as being the weight of a column of mercury, one square inch in section, 29·905 inches in height, at the temperature of 0° C., and weighed at sea-level in the latitude of London. Its actual value in pound-weight per square inch is nearly 14·7; so that 152·3 atmospheres of pressure is equivalent to a pressure of one ton per square inch.

In *gases* the relation between pressure and volume is given by Boyle's Law (see GASES)—viz. the volume of a given mass of gas is inversely proportional to its pressure. From this it follows that the compressibility is inversely proportional to the pressure—i.e. the diminution of volume due to a given increment of pressure is correspondingly small as the pressure is great. The behaviour of a gas under pressure is closely related to the proximity of its temperature to the critical point (see CRITICAL TEMPERATURE); for if below this temperature the gas can, and if above it, cannot be liquefied by pressure alone. It is only since 1877 that liquefaction has been effected in those gases formerly termed permanent.



From the first attempts to compress liquids it was concluded that they were incompressible, but Canton in 1762, by a comparatively simple experiment, showed that the compressibility of water though small is quite appreciable, and that it is less at higher than at lower temperatures. The measurement of the compressibility of liquids is usually made in a glass vessel (see fig.) termed a piezometer. A tube, ABCD, open at one end, D, is bent upon itself between C and D, widened at one end into a cylindrical bulb, AB, and at the other into a cistern, D. The liquid experimented on fills the bulb and stem to C, from which point to D, mercury fills the tube. On the surface of the mercury at C an index floats. The instrument is placed in a larger and much stronger vessel containing water to which pressure (measured by an attached gauge) is applied. The contents of the piezometer being thus compressed, the mercury column ascends in the stem, and when the pressure is relieved the index is left at that point to which the mercury rose under the highest pressure applied. The actual amount of compression, and the original volume, as well as the pressure, being known, the compressibility can be thereby calculated, a correction being finally added for the compression of the glass piezometer itself. From experiments made with such apparatus, the following conclusions (see *Report on some of the Physical Properties of Fresh Water and Sea-water*, by Professor P. G. Tait; *Challenger Expedition Commission Reports*, Physics and Chemistry, part iv.) seem now to be well established regarding the compressibility of liquids, more especially of water. The compressibility of water decreases as both the temperature and pressure are raised; under moderate pressures (e.g. one or two atmospheres) it has a point of minimum value about 60° C., while its actual value at 10° C. and at a pressure of one ton per square inch is very nearly $\frac{1}{21400}$. Sea-water is less compressible than fresh water; the ratio of the compressibility of the former to the latter being ·915. Solutions of common salt are less compressible as they are stronger; the compressibility falling off uniformly with increased strength. Both sea-water and salt solutions diminish in compressibility with temperature and pressure in the same manner as fresh water. It has also been proved that the maximum-density point of water is lowered by pressure; the actual amount of this lowering being 3°·1 C. per ton—i.e. water under a pressure of one ton per sq. in. has its maximum density point at 0°·9, instead of at 4°, as under ordinary atmospheric pressure.

The compressibility of solids is generally very much smaller than that of either liquids or gases. It is best measured by noting the shortening of a rod or fibre of the material tested while subjected to hydrostatic pressure; the linear compressibility thus obtained is, to a sufficient degree of approximation, one third the cubical compressibility. For glass it is ·0000265 per atmosphere.

Concrete. There is but little difference between concrete and coarse mortar. The mortar used in the masonry of castles and churches erected during the middle ages is in fact a concrete with small pebbles instead of the larger ones used in modern concrete. Any mixture of lime, sand, and water, with broken stones or bricks, bits of slag, gravel, or other hard material, is called a concrete. The hard lumps are termed the *aggregate*, and the mortar in which they are embedded is called the *matrix*. The mixture varies with the nature and quality of the materials, but it often consists of 1 part of quicklime, 2 of sand, and 5 of gravel. It is better to use such a material as broken stone rather than water-rolled gravel, which has often too smooth a surface. Lime concrete, as the kind above described may be termed, is used principally for foundations, that is, a thick bed of it is formed below the lowest course of stones or bricks in walls, in cases where the ground itself is not sufficiently firm and solid. Not unfrequently, in some countries, walls themselves are formed of concrete, by laying a foot or two of it in height at a time between boards, and giving it some time to harden. It then forms an artificial stone. Other methods of building walls of concrete are in use.

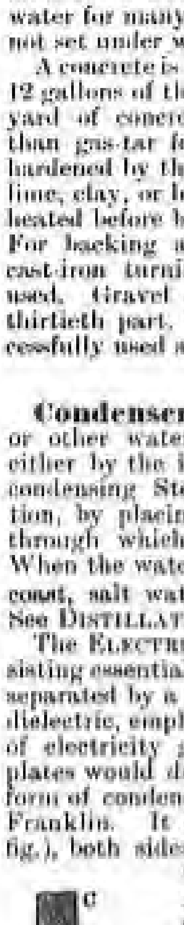
Portland cement concrete is made either by mixing it with gravel alone, or more generally by using the cement along with sand and broken stones. The concrete used at Portland Breakwater Fort and at Cork Harbour have nearly the same composition. The cubic yard of it at the former place was made by using of Portland cement 5 cubic feet, of sand 10 cubic feet, and of broken stones (not more than 3$\frac{1}{2}$-inch gauge) 28 cubic feet, along with 23$\frac{1}{2}$ gallons of water. A concrete with these materials in much the same proportion has been used at other places, but different proportions are also employed. Portland cement being the binding material in this concrete, the question arises whether there is sufficient experience of its durability, especially where it is exposed to the action of sea water, to warrant its employment in structural works of great or even of moderate size. See CEMENTS.

Concrete made of the hydraulic lime from Teil in France, which contains 66 per cent. of silicate of lime, has been employed in the construction of breakwaters and similar works at Cherbourg, Marseilles, and other places. The Teil hydraulic lime is one of the strongest known, and the concrete made with it has resisted the action of sea-water for many years. Ordinary lime concrete does not set under water.

A concrete is made of broken stones and tar, about 12 gallons of the latter being used for every cubic yard of concrete. Bitumen or asphalt is better than gas-tar for this purpose, and either may be hardened by the introduction of dried and pounded lime, clay, or brick-dust. The materials should be heated before being mixed with the tar or bitumen. For backing armour-plates in forts a concrete of cast-iron turnings, asphalt, and pitch has been used. Gravel mixed with rather more than a thirtieth part, by bulk, of iron borings, was successfully used as a concrete at Stranraer pier.

Condenser is an apparatus in which aqueous or other water is condensed into a liquid form either by the introduction of cold water, as in the condensing Steam-engine (q.v.), or as in distillation, by placing the condenser in another vessel, through which a current of cold water passes. When the water-supply is deficient at sea or on the coast, salt water may be distilled and condensed. See DISTILLATION, GAS.

The ELECTRIC CONDENSER is an apparatus consisting essentially of two parallel conducting plates, separated by a layer of non-conducting material or dielectric, employed to receive and retain quantities of electricity greater than either or both of the plates would do alone. The simplest and typical form of condenser is that which was first used by Franklin. It is simply a sheet of glass, C (see fig.), both sides of which, excepting a margin at the edges, are covered with tinfoil, A and B. To charge such a condenser, one of the sheets of tinfoil, say B, is connected with the ground, E (either by some metallic connection or by being placed on the hand of the experimenter), while the sheet, A, remains insulated. If A be now charged with electricity, positive for example, a negative charge is induced on that side of B nearer A, while an equal quantity passes to the ground. Increasing the charge in A induces a corresponding increase in B. This process, although by means of it large quantities of electricity may be accumulated, cannot go on indefinitely; for on reaching a certain limit, depending on the dimension, &c. of the apparatus, the nature of the dielectric used, and the difference of potential of the two conducting plates, either a *disruptive discharge* (see ELECTRICITY) takes place, or the charge passes off through the insulating supports of the condenser.



All the various forms of condensers satisfy the definition given above. One useful form is that in which the two conducting plates are fixed on the ends of brass rods which pass through brass knobs on the tops of two glass pillars, the dielectric in this case being air. The more common form, however, is the Leyden Jar (q.v.). Another is made up of sheets of tinfoil and paraffined paper, placed alternately in layers; the first, third, fifth, &c. sheets of tinfoil are connected to one terminal, and the second, fourth, sixth, &c. to another.

The *capacity* of a condenser is defined to be that quantity of electricity with which one plate must be charged in order to raise its potential by one unit. It can be shown that, in the case of condensers of the Leyden jar form, the capacity is numerically equal to the product of the outer and inner radii of the coating, divided by the difference of the radii—i.e. is greater as that difference is less. Hence the thinner (within certain limits) the glass between the two coatings of such a condenser, the greater is its capacity.

Condiments, or seasoning agents, are those substances which are employed at table for the purpose of imparting a flavour or seasoning to the ordinary solid or liquid food. The principal condiments are saline substances, such as common salt; acidulous bodies, such as acetic acid or vinegar; oily condiments, such as butter and olive-oil; saccharine substances, such as sugar and honey; and aromatic and pungent condiments, such as mustard, ginger, pepper, and pickles.

Conductors and Non-conductors of Electricity. When an electrified body is placed upon a metallic stand, so that it is in metallic connection with the earth, all traces of electrification disappear; but if placed upon supports of glass or ebonite, its charge is still retained, the body then being said to be *insulated*. In the former case, the electric charge having passed to the ground through the metallic support, the metal is termed a *conductor of electricity*; in the latter, the glass or ebonite is termed a *non-conductor* or *insulator*, since by its means the charge is prevented from leaving the body. This distinction is somewhat artificial, since no substance is known to be either a perfect conductor or an absolute insulator. The substances in frequent use as conductors and non-conductors may be arranged in the following order of their conductivity, beginning with the best: Silver, copper, gold, brass, zinc, platinum, iron, tin, lead, mercury, German-silver, graphite, red phosphorus, mineral acids, saline solutions, sea-water, pure water, alcohol, wood, ice, vegetable oils, lime, chalk, camphor, porcelain, wool, hair, silk, glass, wax, sulphur, resin, amber, gutta-percha, shellac, paraffin, ebonite, air and other gases.

It is found that the efficiency of a non-conductor, when used as an insulator in electrostatic experiments, depends very largely on the state of its surface. In a damp atmosphere, glass becomes coated with a thin film of moisture which considerably lessens its insulating power. Hence these experiments succeed better in dry weather; otherwise the apparatus requires to be heated, or the glass insulators employed to be coated with shellac varnish, upon which moisture does not so readily deposit. In metals, conducting power decreases when the temperature is raised; on the other hand, glass, wax, sulphur, and some other bodies which are extremely bad conductors at ordinary temperatures, conduct very much better when raised to a sufficiently high temperature. It has been observed that a series of metals arranged in order of their electrical conducting powers, exhibits the same order as when similarly arranged for their thermal conducting powers; in other words, metals which conduct electricity well, conduct heat well. Also, that when two specimens of the same metal differ in electric conductivity, they differ in thermal conductivity, and in the same way. See LIGHTNING CONDUCTOR.

Convulsion, in Medicine, is sometimes used of any involuntary contraction of the voluntary muscles of the body; but especially of seizures in which the body is thrown into violent spasmodic contractions, the sensibility and voluntary motion being for a time suspended. In adults convulsions almost always indicate the presence of grave disease, either of the brain (particularly Epilepsy, q.v.) or of the kidneys. In children, especially before the age of three years, they are of much more common occurrence, and, though serious in themselves, may be due to temporary and comparatively trifling causes. The following description applies chiefly to the convulsions of children. A fit of convulsions may last from a few minutes to some hours, and may readily prove fatal, if not relieved within a short period. The first symptom observed is often a twitching of particular muscles or groups of muscles, and a change in the habitual expression or colour of the face, with distension of the features, and turning of the globes of the eyes suddenly upwards. The fingers are sometimes clenched in the palm, and the feet turned inwards; sometimes, however, convulsions occur absolutely without warnings of this kind, and even in the midst of perfect apparent health. Their cause is usually to be found in some source of irritation, especially in the digestive organs; as, for instance, disordered dentition, worms in the intestine, indigestible or unsuitable food, &c. Most epidemic fevers are also apt to be attended, in children, by convulsions in their early stages, and if severe, particularly in the case of whooping-cough, during their progress as well; and diseases of the brain and its membranes at every stage. Convulsions are greatly promoted by bad ventilation and injudicious feeding, with deficient exercise; and a great part of the cure consists in discovering and removing the causes of the disease.

When a child is suddenly seized with a tendency to spasm, such as twitching of the features, or contractions of the fingers and toes, it should be placed at once in a very free current of air, with its feet towards the fire; the extremities should be kept warm, and a cold lotion may be applied to the head, especially if there is much flushing of the face; a little castor-oil may be given unless the bowels are loose; and if there is flatulence, the belly may be rubbed with a warm hand, or with some simple stimulating liniment, such as camphorated oil. If an actual convulsion occur, the feet, or if possible the whole body, should at once be put in hot water to which a little mustard has been added, and cloths wrung out of cold water frequently applied to the head. If there is any suspicion that worms or undigested food may be the cause, a purgative Clyster (q.v.) should be given; and aperient medicine by the mouth as well, if the child be able to swallow. Nothing more should be attempted without medical advice. The further treatment generally consists in the administration of nerve sedatives, especially bromide of sodium or potassium and chloral, and in obstinate cases chloroform, with careful attention of course to any cause of irritation that may be present.

Convulsions are rare amongst horses and cattle. In young dogs, however, they frequently occur from intestinal worms, disordered digestion, or in connection with distemper or other debilitating diseases; they usually disappear when their special causes are removed.

Copaiba, or COPAIVA, BALSAM OF, a valuable drug, consisting chiefly of a resin (resin of copaiba) and a volatile oil (oil of copaiba). It flows from incisions in the stems of various species of copaifera trees, natives of the American tropics, which belong to the natural order Leguminosæ. When these trees become old or surcharged with copaiba, it is no unusual thing for the stems to burst with a loud booming sound. The balsam has a peculiar, aromatic, but not disagreeable odour, which, however, is highly persistent, while its taste is decidedly acrid. It has stimulant properties, is diuretic, laxative, and in large doses often an active purgative. It is, however, mostly on account of its powerful action on the mucous membrane that it is used, and it is accordingly much employed in affections of the urino-genital system, in chronic catarrhs, &c. The resin itself has been found efficacious given in the form of a cough-pill. Balsam of copaiba is sometimes adulterated with castor-oil or volatile oils. The former of these is readily detected if any milkiness is produced when the balsam is shaken with ten times its volume of petroleum benzin. The volatile oils may be recognised by shaking the balsam with a little alcohol, when, being more soluble, they are removed first.

Copal, a resinous substance used for a variety of purposes in the arts. It appears in commerce in smooth rounded masses, colourless or lemon-yellow, translucent or transparent, rather brittle, and in a cold state, almost without smell or taste. It is readily fusible and inflammable, is insoluble in water, and only partially soluble in alcohol and oil of turpentine, but becomes entirely soluble in them when it has been for a short time melted. Various useful pale-yellow or almost colourless varnishes and lacquers are made by dissolving melted copal in alcohol, oil of turpentine, or boiled linseed-oil. The chief sources of copal are the East Indies, Africa, and South America, but the varieties derived from these countries differ in their origin. The East Indian is the exudation of a large tree, *Vateria Indica*, and possibly also of different species of Hymenea, which probably yield the Brazilian variety. Much copal is obtained from West Africa, where it is found in rounded masses, embedded in sandy soil. *Gum Animé* is the name applied to a copal of this nature.

Copalchi Bark, a bark resembling Cascarilla Bark (q.v.) in its properties, and produced by a shrub of the same genus, *Croton niveus*, a native of Central America (see CROTON). The bark is in quills a foot or two in length, and has a thin corky epidermis. Copalchi Bark is much used as a substitute for cinchona in Mexico, where it goes by the name of *Quina blanca*, and is imported, although not to a large extent, into Europe. It contains a minute proportion of a bitter alkaloid resembling quinine.

Copper. This appears to have been the first metal employed by man both in war and the peaceful arts. Like gold and silver, it is found native, but, except in one or two districts, only to a small extent. It can, however, be extracted from its ores at a comparatively low heat, and it is not altered by exposure to dry air; although in moist air, in the presence of carbonic acid, it soon takes on a coating of the green carbonate of copper. The use of copper by ancient nations is well known, through the weapons and other objects of Bronze (q.v.)—that is, copper mixed with a small quantity of tin, &c.—which have been so largely collected by archæologists. Some prehistoric implements are, however, of unalloyed copper. It was obtained by the ancients from various places, but especially from Cyprus—whence the name. Copper has a characteristic fine red colour and takes a brilliant polish. It is nearly nine times heavier than water, its specific gravity being from 8·8 to 8·95. Next to silver it is the best conductor of heat and electricity, hence its many useful applications. Its point of fusion lies between silver and gold, but unlike these metals, it absorbs oxygen when strongly heated in the air, and scales of black oxide form rapidly on its surface. Copper is moderately hard, and is highly malleable, ductile, and tenacious, although not so strong as iron. When held, in the form of sheet or wire, in a flame, it communicates to it a highly characteristic green colour. Whereas steel is hardened by being heated to redness and suddenly cooled in cold water, copper is softened by the same process. Copper forms two important compounds with oxygen—cuprous and cupric oxides.

Cuprous Oxide (red oxide, sub-oxide), Cu_2O. This is obtained by heating to redness the black oxide with nearly its own weight of finely divided copper in a well-covered crucible, to protect the mixture from the oxidising action of the air. It is got as a hydroxide by adding grape-sugar to a solution of sulphate of copper, and then caustic soda, till a blue precipitate, which is first formed, is redissolved. The solution, on being gently warmed, deposits the hydroxide as a rich orange-yellow powder. On continuing the heating till the liquid has reached the boiling-point, and maintaining the ebullition for some time, the powder changes into the red anhydrous oxide. This oxide is used in colouring glass a fine ruby tint. It is not acted on by air or moisture, and for this reason is produced on copper surfaces as a bronze to keep the metal itself from becoming stained. The salts of this oxide are generally colourless, but they are liable to absorb oxygen and pass into the blue-coloured cupric salts. Cuprous chloride is the most important salt, being used for absorbing carbonic oxide in gas analysis.

Cupric Oxide (copper monoxide, black oxide), CuO, is the scale or rust of copper which peels off the surface of the metal when heated. It is got for chemical purposes by heating nitrate of copper to redness in a crucible with occasional stirring, and carefully avoiding any possible admission of coaly matter. By the use of cupric oxide Liebig established the method by which the composition of all organic substances has been determined, as it readily gives up its oxygen at a red heat to carbon and hydrogen, converting them, respectively, into carbonic acid and water, from the weight of which the composition of the organic body is calculated. This oxide is used for staining glass, to which it imparts a green colour; and its solution in ammonia has the remarkable property of dissolving cotton fibre. The *Hydroxide*, $Cu(OH)_2$, is obtained as a blue precipitate by adding caustic soda to sulphate, or other salt, of copper, which, as in the case of the cuprous oxide, becomes anhydrous on boiling, the blue precipitate becoming black and granular. The salts of cupric oxide are readily obtained by dissolving it in the necessary acids; for example, in sulphuric acid for the sulphate, and in nitric acid for the nitrate of copper.

Cupric Sulphate (sulphate of copper, blue vitriol), $CuSO_4$, occurs native in veins of copper and iron pyrites, and is manufactured on a large scale by gently roasting native copper sulphide (copper pyrites), when oxygen is absorbed from the air, the anhydrous sulphate thus obtained being dissolved in water, and from this solution the salt as found in commerce crystallises out. The crystals are large, transparent, and have a fine blue colour. They are much used by the dyer and calico-printer, in electroplating, and in the preservation of organic materials.

Cupric Nitrate, $Cu(NO_3)_2$. The crystals of this salt are of an intense blue colour and deliquescent. It is much used in calico-printing as an oxidising agent.

Cupric Cyanide, $CuCy_2$, along with cyanide of potassium, gives the solution from which copper is deposited on an iron surface. It is not, however, necessary to prepare pure cupric cyanide, as the sulphate in excess of potassium cyanide serves the purpose.

Cupric Arsenite, $CuHAsO_3$ (Scheele's green), is a well-known green pigment, got by adding an alkaline arsenite to cupric sulphate, and washing the precipitate till free from sulphate, and drying. This colour has been much used for wall-papers, but has been supposed to have insanitary effects. See ARSENIC.

Copper Acetate, $Cu(C_2H_3O_2)_2$, is got by adding copper hydroxide, or carbonate, to acetic acid. It forms dark blue prisms. If acetic acid is allowed to act on metallic copper in the presence of air and moisture, a basic acetate is slowly formed termed *verdigris*; this has less acetic acid than the previous compound, and is much less soluble. It has a bluish-green colour. Verdigris and arsenious acid boiled together in water form the fine colour termed *emerald green*—an aceto-arsenite of copper.

Copper Stearate is obtained by adding stearate of soda to sulphate of copper in hot solutions. It is a light bluish-green powder used for colouring candles.

The pigment, *Brunswick green*, used in the arts, is an oxychloride of copper.

Copper in any liquid is easily discovered by placing in it a plate of polished iron, when it will be observed coating the metal with its well-known reddish tint, making its appearance over the part of the plate immersed in the fluid. If the quantity of copper is very small, the liquid should be concentrated till it half fills a watch-glass, and a bright steel needle used in place of an iron plate. Solutions of cupric salts have a blue or greenish-blue colour, but this on addition of ammonia in excess becomes an intense purplish blue.

Native Copper, although frequently met with wherever copper ores occur, is yet rarely discovered in sufficient quantity to admit of its being systematically worked. It is found crystallised in cubes and in modifications of this form; also in arborescent pieces, in thin laminæ, and in irregular lumps or masses. Sometimes it forms a nucleus with first a layer of red oxide and then a second layer of carbonate of copper around it. The largest masses of native copper are obtained from mines in Russia and from copper-bearing strata in the neighbourhood of Lake Superior. One mass was mined at Minnesota in 1859, weighing 500 tons, which required the work of forty men for a year to extract it. The largest yet obtained was got in 1866 at the Central mines, Lake Superior, and weighed 800 tons.

The ores of copper are numerous. *Cuprite, ruby copper, cuprous oxide, or red oxide of copper*, is the richest ore. It contains, when pure, nearly 90 per cent. of copper. *Malachite* (q.v.), or *green carbonate of copper*, consists, when pure, of 57 per cent. of the metal. This ore occurs largely in Russia, South Australia, and in some localities in South America. *Chessylite, azurite, or blue carbonate of copper*, in a pure state contains 55 per cent. of copper. *Chalcopyrite, copper pyrites, or yellow copper ore*, a sulphide of copper and iron, is, from its abundance, the most important of copper ores. Although containing, when pure, 35 per cent. of copper, yet on account of impurities, what is mined in England does not yield, on an average, more than 8 per cent. of the metal. Some of the auriferous copper pyrites of the western states of America and elsewhere is worked as an ore of gold (see GOLD). *Erubescite, or purple copper ore*, is also a sulphide of copper in which the proportion of the metal varies from 60 to 70 per cent. *Tetrahedrite, or grey copper ore*, is a sulph-antimonite of copper of very variable composition, but often containing from 30 to 40 per cent. of copper, &c. *Atacamite* (q.v.) is an oxychloride of copper mined in Chili, and found in other countries. *Melaconite, or black oxide of copper*, and *Chrysocolla*, a silicate of copper, are sometimes smelted as ores of the metal.

COPPER-SMELTING.—In practice, the process of smelting copper from ore (copper pyrites) like the Cornish is somewhat complicated, but in theory it is comparatively simple. The main impurities of the ore are quartz, iron, sulphur, and very commonly arsenic. The process is conducted with the view of separating the iron and quartz as a fusible slag, and of dissipating the sulphur and arsenic, by converting them into sulphurous and arsenious acids, through oxidation in the furnace. At Swansea, which is the chief seat of copper-smelting in this country, reverberatory furnaces are used, and these are of two kinds, called respectively calciners and melting furnaces. Gas, along with Siemens' regenerative apparatus, is now to some extent used in different parts of the world for supplying heat to copper furnaces, but at some places it has been given up, after a short trial, owing to the costly repairs which it causes. There are never fewer than *six operations* in the Welsh process of copper-smelting, and when so limited, a favourable admixture of ores, such as copper pyrites and copper carbonates, is necessary. In the *first*, the ore is calcined in a furnace for at least twelve hours, by which time the greater part of the sulphide of iron is decomposed, and much sulphurous and other acids have formed and escaped in fumes—i.e. a partial oxidation of the iron and sulphur

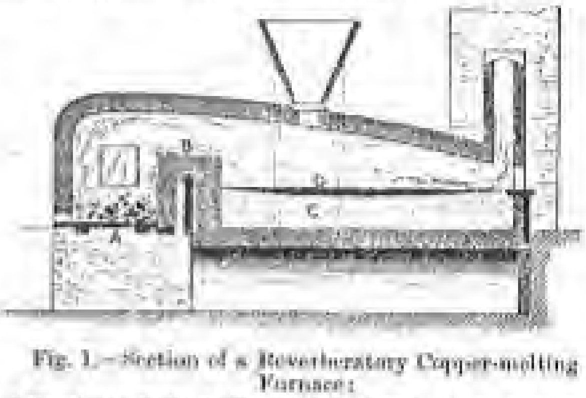


Fig. 1.—Section of a Reverberatory Copper-melting Furnace:

A, fireplace; B, fire-bridge; C, bed of sand; D, melted copper.

takes place. In the *second*, the calcined ore is melted along with siliceous slags obtained in later stages of the process. Here a fusible slag, consisting in great part of silicate of iron, is formed, and the sulphides of iron and copper are run off as a regulus, termed *coarse metal*, and granulated in water. A section of a melting furnace is given in fig. 1. In the *third*, the coarse metal is calcined again for twenty-four hours, during which time most of the sulphide of iron is converted into oxide. In the *fourth*, the calcined coarse metal is melted with slags rich in oxide of copper, and also with rich ores, as oxide and carbonate. These oxidise any sulphide of iron remaining, and a regulus called *white metal* is formed, consisting almost entirely of sulphide of copper, and containing about 75 per cent. of the metal. In the *fifth*, called 'roasting,' the regulus is very slowly melted, so as to allow of the gradual and thorough reduction of the sulphide by heated atmospheric air through the formation of oxide of copper. When oxide and sulphide of copper are heated together, they decompose each other, the sulphur escapes as sulphurous acid, and impure metallic copper, called *blister copper*, is produced, while other foreign bodies are for the most part removed in the slag. In the *sixth*, the copper from the previous operation is refined. To effect this, it is melted in a furnace, and exposed to the oxidising influence of the air for from fifteen to twenty hours, by which time it is full of dioxide, and this is in turn reduced by throwing pure coal on the surface of the molten metal, and then stirring it with a pole of green birch-wood.

At those smelting works where the sulphurous acid produced in the calcining or roasting of copper pyrites is saved for the manufacture of sulphuric acid, peculiar furnaces, such as Gerstenhöfer's, Hasenclever and Helbig's, and Maletra's, are used for roasting the ore. Shaft or cupola furnaces, instead of those of a reverberatory kind, are used in some countries, for smelting copper ores where these are highly ferruginous, or oxidised, or comparatively poor. Coke, anthracite, or charcoal is used as fuel in cupola furnaces, which require a blast of air at a moderate pressure.

Wet Copper Extraction Process.—Soon after iron pyrites (sulphide of iron) began to be used about thirty years ago as the source of sulphur for the manufacture of sulphuric acid, it was thought desirable to recover the copper, amounting to a small per cent. of the pyrites used. The burnt pyrites, consisting chiefly of oxide of iron, along with 4 or 5 per cent. of copper, is mixed with from 12 to 15 per cent. of crushed rock-salt and the mixture properly calcined, when the whole of the copper is converted into a soluble chloride. The roasted mass is then lixiviated, and the copper contained in the solution thrown down as metal by scrap iron. This precipitate contains about 75 per cent. of pure copper, and is mixed with the copper of the later stages of purification got in the dry process.

APPLICATIONS OF COPPER.—The metal is used for a great variety of purposes. It is most largely consumed along with zinc in the production of Brass (q.v.). To a less, but still considerable extent, it is made into bronze and gun-metal, in which it is alloyed with tin and other metals (see BRONZE). Alone it is employed for boilers, stills, cooking vessels, seamless and other pipes, wire and wire-cloth, nails, and spikes. In the form of thin plates it has long been in demand for engraving and etching upon, and in the shape of strong rollers it is extensively employed for a like purpose by the calico-printer. Copper does not cast very well, but it is admirably adapted for producing works of art in electro-deposit instead of casting them. This process is extensively employed, and does even for objects as large as life-sized statues. In this way engravings and pages of type are also copied for the printing-press. For its use in coating other metals, see BRONZING. Copper is the metal usually chosen for lightning conductors. Writing pens are made of an alloy consisting for the most part of copper, and for some purposes are better than those made of steel, as they do not corrode nearly so soon. These pens are usually white in colour. An alloy of copper, 'yellow metal,' is used for sheathing the bottoms of timber ships, so as to prevent molluscs and seaweeds from encumbering them. Copper, owing to its ductility, may be made into pipes, tubing, &c., by high pressure alone, without heat.

Copperas is the commercial term for the sulphate of iron, and is used extensively in dyeing black, in making ink, and has been found useful as a dressing for crops.

Coriander (*Coriandrum sativum*), an annual plant of the natural order Umbelliferæ, with branching stem, 1 to 2 feet high, the lower leaves bipinnate, the upper leaves more compound, and globose fruit. It is a native of the south of Europe and of the East, and has long been cultivated for the sake of its fruit; and has thus become naturalised in some parts of England, although its fruit (coriander seed) is much less used in Britain than in Germany and some other European countries. The whole plant, when fresh, has a very offensive smell; but the ripe and perfectly dry fruit has an agreeable aromatic smell and a sweetish aromatic taste. It is used in medicine as a carminative, and as a corrective of certain purgatives; also in domestic economy as an aromatic, being very often mixed with bread in the north of Europe; spirituous liquors are flavoured with it; and confectioners cover it with sugar to make a well-known kind of comfit. In the south of England it is common to sow coriander and caraway together, the coriander yielding a crop in the first year, and the caraway in years following. Coriander delights in a rich soil, and is much cultivated and used in India.

Corrosive Sublimate, the popular name of the highly poisonous bichloride of mercury (mercuric chloride). See MERCURY.

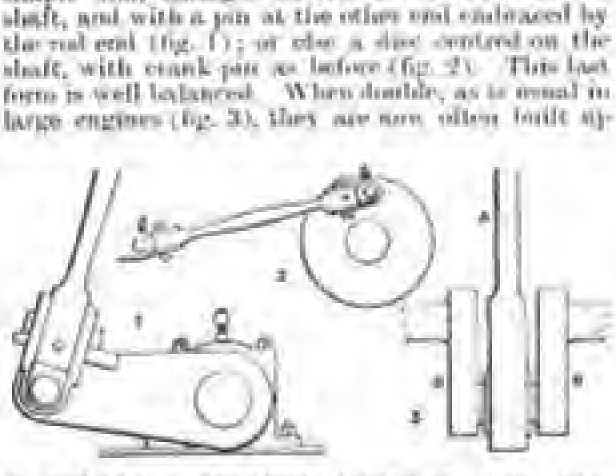
Corrugated Metal. Iron and other metals in sheets and plates have communicated to them enormously increased rigidity and power to resist buckling and collapse by being corrugated. The process is merely an application to metallic substances of the old contrivance of 'goffering' or 'piping,' by means of which frills are stiffened and kept in shape. The metal to be corrugated is passed between pairs of rollers with ridged surfaces, the ridges of one fitting into the hollows of the other, and the sheets or plates operated on are bent and compressed into the wavy outline of the rolls. Walls and roofs of light and temporary buildings are extensively made of corrugated galvanised iron—i.e. sheet-iron first corrugated and subsequently coated with zinc by dipping the sheets into a bath of the liquid metal. The most important mechanical application of corrugated metal has been for the flues of large steam-boilers. About 1878 a system of annular corrugated iron flues was introduced, which increased the resistance of the flue to collapse, and saved fuel because of the greater heating surface presented by the corrugations. A spiral corrugated flue gives the greatest amount of strength.

Counter-irritants, agents applied to the skin so as to redden (rubefacients), to vesicate (vesicatories or Blisters, q.v.), or to produce pustules, purulent issues, or even sloughs of skin and of the subcutaneous textures. The milder counter-irritants are mustard (see CATAPLASM), turpentine applied on warm cloths, and spirit or acetic acid in lotion. The stronger are blisters of Cantharis (q.v.) or of ammonia; of Croton-oil (q.v.) or Tartar Emetic (q.v.), in ointment; setons, caustic or pea-issues, and the moxa; and above all, the actual Cautery (q.v.) or hot iron. None of the stronger counter-irritants should be used without careful consideration and medical advice; great mischief is often done by their careless or improper use. Counter-irritants relieve internal pain, check inflammations, and tend to promote the absorption of morbid effusions. Their effect is probably due mainly to reflex action, produced by the impression they cause upon the nerves of the skin to which they are applied.

Amongst horses, counter-irritants are much used for strains and diseases of the joints, but should never be applied, as they too often are, in recent cases, or whilst the part is hot or inflamed. Cantharidine preparations, or ointment of biniodide of mercury, are the most convenient. For cows, use fomentations, followed by the smart infriction of mustard-paste; for dogs, soap-liniment, strengthened, if required, by ammonia or turpentine.

Cowhage, COWAGE, or COWITCH, consists of short, slender, brittle hairs, which cover the pods of species of Mucuna, a papilionaceous climber, particularly *M. pruriens* of the West Indies and *M. urens* of the East. These hairs readily stick in the skin and cause intolerable itching, and were hence formerly used (as still in their native country) as a vermifuge. They are administered in syrup, and of course act mechanically. The unripe pods are eaten like kidney-beans.

Crank, in Machinery, is a lever or arm on a shaft, driven by hand (e.g. a winch-handle), or by a connecting-rod, its object being to convert reciprocating motion into rotary motion. Engine-cranks which convert the to and fro motion of the piston into continuous rotation of crank-shaft are connected to the piston-rod end by the connecting-rod. They are, when single, of steel, wrought-iron, or cast-iron, the crank in this case being either a simple arm, enlarged at one end to fit over the shaft, and with a pin at the other end embraced by the rod end (fig. 1); or else a disc centred on the shaft, with crank-pin as before (fig. 2). This last form is well balanced. When double, as is usual in large engines (fig. 3), they are now often built up



of steel, the two arms being shrunk on to the shaft, and pin on to them. In two positions during each turn, a connecting-rod exerts no power of rotation. These are when rod A and crank-arms B are parallel (as in fig. 3 and opposite position), and are the *dead centres*; all the push or pull of the rod only causes pressure on shaft-bearings. To carry the crank over these points either a heavy wheel (fly-wheel) is attached to the shaft, which stores up energy during other parts of the revolution, and gives it out at these points, or else two or more cranks are so placed on the shaft that when one is on its dead centre, the others are exerting nearly their maximum effort, which is when rod and crank are at right angles.

Cream of Tartar exists naturally in grape juice, but being insoluble in alcohol, it is gradually deposited, in the form of argol, as the sugar of the juice becomes converted into alcohol by fermentation. In the preparation of cream of tartar the argol is dissolved in hot water, to which charcoal or fine clay is added, to take up the colouring matter; by boiling and filtering a clear colourless solution is obtained, from which, on cooling, the cream of tartar separates as crystals. These crystals, after being exposed on linen for several days, become whiter and constitute the *crystals of tartar*, or, when ground to powder, the *cream* of tartar. Although cream of tartar is, practically speaking, the bitartrate of potash, $KHC_4H_4O_6$ (see TARTARIC ACID), yet it usually contains from 5 to 10 per cent. of tartrate of lime, while adulterants, properly speaking, may also be present. The tartrate of lime is derived from the clay added to purify it, and is more or less present in all commercial samples. In 1888, however, cream of tartar was offered in the market containing 99 per cent. of bitartrate of potash, so that it may be assumed that in future a purer article will be forthcoming. Cream of tartar is readily soluble in hot water, though it takes 60 parts of cold water to dissolve one part of it. *Soluble cream of tartar* is prepared by dissolving together 2 parts of Borax (q.v.) and 5 parts of cream of tartar, evaporating to dryness and powdering. Cream of tartar has an acid taste and gritty feel. When taken repeatedly in small doses of a scruple to a drachm, it acts as a refrigerant and diuretic; in doses of one to two drachms, it is useful as an aperient; and in larger doses of from two to three drachms it acts as a purging agent, accompanied by flatulence and griping. *Imperial liquid* is prepared by dissolving about a drachm of cream of tartar in a pint of boiling water, and adding a little lemon peel and sugar to flavour it; when an agreeable refrigerant drink is obtained, which is highly serviceable in allaying thirst in feverish cases. Cream of tartar whey is obtained by adding two drachms of the salt to a pint of milk.

Creasote (Gr. *kreas*, 'flesh;' *sozo*, 'I preserve') is an oily substance obtained from the tar produced by the destructive distillation of wood. When Coal-tar (q.v.) is distilled, a certain portion called creasote oils passes over, and from this much of the creasote of commerce is obtained. This, although similar in some respects to wood creasote, is quite distinct chemically. The coal product consists largely of carbolic acid, along with cresol and xylenol, while the wood product, to which alone the name creasote rightly belongs, consists of guaiacol, cresol, and phlorol. As it contains several substances, so its boiling-point ranges from 392° to 428° (200°-220° C.). The leading character of wood creasote is that it instantly coagulates albumen, but does not coagulate Collodion (q.v.), in this respect differing from carbolic acid. It has a very remarkable power of arresting the decay of meat or wood, and when meat is treated with so small a proportion as one-hundredth of its weight of creasote, and exposed to the air, it does not putrefy, but becomes hard and dry, assuming the taste and odour of smoked meat. Indeed, there can be no doubt that hams cured by means of wood smoke owe their preservation and flavour to some extent to the volatile creasote in the smoke. Railway sleepers and wood liable to be frequently wet are often saturated with the coal tar creasote; or, where economy is not so essential, with the wood creasote, and are thereby preserved indefinitely. In toothache, where the cause of pain is a carious tooth with an exposed, inflamed nerve, a drop of creasote, carefully inserted, after previously cleansing the cavity, will often give relief. In this case it acts by coagulating the albumen and destroying the nerves. Creasote acts powerfully on the skin, producing a white stain when applied to it. A few drops added to a pint of ink preserve it from mouldiness. Medicinally, it is given in doses of one or two drops, and has been found efficacious where there is a tendency to fermentation of the contents of the stomach and bowels. Owing to its action on the skin it acts as an energetic poison when taken in large doses.—The Creasote Plant (*Larrea mexicana*), growing abundantly on the borders of the Colorado Desert, emits a strong odour of creasote. The odour arises from an exudation similar to Indian gum-lac, and is caused by the punctures of an insect, *Carteria Larreæ*.

Creatin, or KREATIN (Gr. *kreas*, 'flesh'), a constant and characteristic constituent of the striped muscle of vertebrates. It was discovered by Chevreul in 1835, but little was known about it till Liebig published his researches on the *Chemistry of Food* in 1847. Its chemical formula is $C_4H_9N_3O_2$. Except in one doubtful case, it has always been found as above indicated; it is very uncertain if it ever occurs in unstriped muscles, and it has never been demonstrated in invertebrates. A dehydrated form, known as *Creatinin*, $C_4H_7N_3O$, occurs as a constant constituent of urine, and has also been demonstrated in fish muscles. Under the influence of acids, creatin becomes creatinin, and by hydration the transformation may be reversed. As these changes may readily occur during extraction, there is often doubt whether creatin or creatinin is present in a given case.

Cricket (*Gryllus*), a familiar genus of insects in the order Orthoptera, near locusts, grasshoppers, &c. A substantial body, a thick head, long feelers, a rasping organ on the wing-covers of the males, wings closely folded lengthwise, but often along with the wing-covers degenerate, great powers of leaping, and a retiring, more or less subterranean habit of life, are some of the more important characteristics of the family (Gryllidæ) of which the cricket is a type. The females are fertilised by means of peculiar spermatophores, and as in allied Orthoptera there is no marked metamorphosis in the life-history. In the genus Gryllus the head is blunt, the antennæ are long and thin, the wings are always present, the hind-legs are very broad and strong, and the females have a straight protruding egg-laying organ.—The Field Cricket (*G. campestris*) is very common throughout Europe in fields and meadows (local in England), and is very well known from the sound, by means of which the male captivates his mate. The body is compressed, the head is black and shining, the wing-covers are brown and yellow at the roots. As in other crickets, the noise of the males is made by rubbing the wing-covers against one another. The under side of one of the nervures bears over a hundred sharp transverse ridges or teeth. These insects hide in burrows in the ground, and sometimes do much damage to vegetables. The female lays numerous eggs in the burrow, and the larvæ remain as such through the winter.—The House Cricket (*G. domesticus*) has a lanker, yellowish-brown body an inch long. A recent arrival in the United States, it is common throughout Europe in houses, is said to occur in the open air in Madeira, and even in Britain occasionally wanders out of doors in summer. It hides in nooks and crevices, and loves the neighbourhood of the fire, especially in winter. Its merry note has become associated with ideas of domesticity (as in Dickens's *Cricket on the Hearth*).

House Cricket (*Gryllus domesticus*):
a, full-grown larva; b, pupa; c, perfect insect.

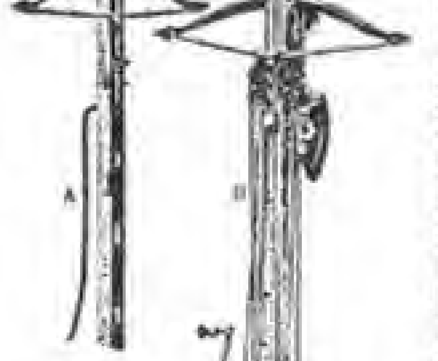
Without the heat of the fire, it becomes more or less dormant in winter. It remains quiet during the day, but hunts about actively at night

Mole Cricket and eggs (*Gryllotalpa vulgaris*).

for crumbs and other scraps both animal and vegetable. For the sake of both food and warmth it often frequents bakehouses. The larvæ are wingless, and the pupæ have only rudimentary wings. The loudest noise made by a cricket is probably that of a Sicilian species (*G. megalocephalus*), which is said to make itself heard 'at a distance of a mile.' Closely allied to the above genus is Myrmecophila, a wingless cricket with extremely strong hind-legs. Only the females are known, and these live parasitically in ants' nests. The Mole Cricket (*Gryllotalpa*) belongs to the same family, and is distinguished by the enormous burrowing fore-legs, by the large size of the anterior ring of the thorax, and by the absence of an ovipositor in the females. The only European species (*G. vulgaris*) is a large and formidable insect, sometimes attaining a length of two inches. It is of a grayish-brown colour, with a silken sheen. It burrows like a mole in fields and meadows, but is sometimes seen in flight in the evenings. Numerous eggs, inclosed in a cocoon, are laid underground. The larvæ are long in becoming adult. The mole cricket often does damage by biting at the roots of vegetable crops. Like the field cricket, however, it feeds very largely on ground insects and the like. A South American and West Indian species (*G. didactyla*) damages the sugar-canes.

Critical Temperature is that temperature below which a substance may, and above which it cannot, be liquefied *by pressure alone*. This temperature for carbonic acid gas, for example, is 30·9° C.—i.e. below that temperature, the liquefaction of the substance may be easily effected if sufficient pressure be applied; but above it the substance cannot be liquefied, no matter how great be the pressure to which it is subjected. The discovery of the critical temperature by Dr Andrews in 1869 first gave the means of distinguishing between a true gas and a true vapour; for the former is a substance above, the latter one below, its critical temperature. When any substance is at this temperature it is in the critical state—i.e. its passage from liquid to gas, or *vice versâ*, is one in which the two parts, liquid and gaseous, so merge into one another as to render them optically indistinguishable. The critical temperatures of oxygen, hydrogen, and nitrogen (formerly termed 'permanent' gases) are all extremely low, and hence liquefaction can only be effected (as it has already been) by the application of intense cold as well as considerable pressure. On the other hand, such vaporous bodies as sulphurous anhydride, alcohol vapour, ether vapour, &c. can, provided the pressure be sufficiently great, be liquefied at ordinary air temperatures, since these are much below their critical temperatures.

Crossbow, or ARBALIST, a weapon used in war and sport in mediæval times. It consisted of a wooden stock, with a bow made of wood, iron, or steel, crossing it at right angles to the end; the bowstring was pulled down towards the other end of the stock by a lever (which in the simpler kinds was worked by hand or foot), and retained in position sometimes in a notch by a catch or trigger. The bolt, or 'quarrel,' was then laid in a groove on the top of the stock, and the trigger being pulled, it was shot with a considerable amount of power. The latter, of course, depended on the size of the bow, some of the weapons being comparatively small and easily handled, while others were of large dimensions, and required a machine of the nature of a windlass, called a 'moulinet' or 'gaffle,' to enable the bow to be properly bent. The crossbows of the 14th century were almost all thus equipped. The 'quarrels' employed varied with the size of the bow, but generally they were short stout shafts about 18 inches long, winged with horn or leather, and having a metal point, which was sometimes



A, Hand Crossbow; B, Rolling-purchase Crossbow.

sharp, but often lozenge-shaped, obtuse, and indented at the sides. Some crossbows had a tube or barrel, with a slit for the bowstring, and discharged balls of clay, marble, or lead with such force that they were more formidable weapons than the earliest firearms. The larger crossbows were really military engines, which required several men to work them, and threw proportionally heavy missiles (see BALLISTA). The crossbow was used in England chiefly during the 13th century; after that it gave place to the longbow, which was found to be the more convenient and easily handled weapon of the two. Its use, however, was general among the continental nations of Europe after the 12th century; though the Lateran Council of 1139 forbade its use as being too murderous a weapon for Christians to employ against one another.

Croton, a genus of plants of the natural order Euphorbiaceæ, with numerous species, which are mostly tropical or subtropical trees or shrubs, a few herbaceous. The most important is the Purging Croton (*C. Tiglium*), a small tree, a native

Croton.

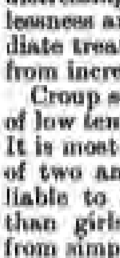
of India and the more easterly tropical parts of Asia. The leaves are extremely acrid; the wood in a fresh state is a drastic, and in a dried state, a more mild purgative; and the seeds (*Croton Seeds*, or *Tilly Seeds*) are a very powerful drastic purgative, formerly much employed in Europe, but latterly disused on account of violence and uncertainty of action, although still valuable as yielding croton-oil. They are oval or oval-oblong, about the size of field-beans. So great is their acridity, that dangerous effects have ensued from working for some hours with packages of them. The oil is obtained mostly by expression, and partly by treating the cake with alcohol. The wood and seeds of *C. Pavana* are employed in some parts of the East in the same way as those of *C. Tiglium*. Other species possess similar properties. Very different are the properties of the species which yield Cascarilla (q.v.) and Copalchi (q.v.) barks. Other species are still more aromatic, and some delightfully fragrant, containing in great abundance a thickish balsamic sap. The sap of *C. gratissimus* is employed as a perfume and cosmetic at the Cape of Good Hope; that of *C. origanifolium* is used in the West Indies as a substitute for Balsam of Copaiva; that of *C. balsamiferum*, also West Indian, furnishes *Eau de Mantes* by distillation; and the balsamic sap of some South American species is dried and used as incense. The *C. Draco* and other species yield a blood-red juice, which, when dried, forms the finest kind of dragon's-blood, and is possessed of astringent properties.

CROTON-OIL is the oil expressed from the seeds of the *C. Tiglium*, and is a sherry coloured, viscid liquid, with an acrid taste, a somewhat rancid smell, and a fluorescent appearance. It contains a number of oily bodies, none of which have as yet been definitely shown to be the cause of its purgative and vesicating properties. Croton-oil is a violent purgative, in most cases a single drop being sufficient to remove constipation. When rubbed upon the skin it produces rubefaction and pustular eruption, and thereby tends to relieve some affections of the internal organs. It is used either by itself in the unmixed state, or diluted with olive-oil, soap liniment, alcohol, &c. It is not to be employed except under the advice of a doctor.

Croup, a term used in Scotland from an early period to describe a certain train of laryngeal symptoms, was first applied by Dr Francis Home, in 1765, to an acute inflammatory and non-contagious affection of the Larynx (q.v.), in which there is the formation of a false membrane or fibrinous deposit on the mucous surface of the windpipe. The invasion of the disease resembles that of simple Catarrh (q.v.), and may be very insidious. The child is languid, feverish, and thirsty, and a dry, shrill cough is gradually developed, but these symptoms sooner or later give way to those of the second stage. Here the respiration becomes difficult, the drawing of each breath having a hissing and 'croupy' sound; the voice is almost inaudible or greatly modified, and accompanied by a harsh, brassy, or may be stifled cough; the face is red and swollen, and covered with sweat; and the nostrils are rapidly working. If the little patient is not relieved by coughing or vomiting up some membraneous shreds and glairy mucus, a state of greater dyspnœa ensues; the lips become livid and the nails blue; the fever is higher, the pulse quicker but weaker; and the child's efforts to relieve the increasing obstruction to the breathing are most distressing to witness. A period of extreme restlessness and suffering is (unless relieved by immediate treatment—see below) soon followed by death from increasing coma, syncope, or exhaustion.

Croup seems to be caused by a damp atmosphere of low temperature, and is got in exposed situations. It is most frequently met with between the years of two and ten, although all ages and classes are liable to suffer from it. It is commoner in boys than girls. Croup requires to be distinguished from simple catarrh of the windpipe; from so-called false croup, a spasmodic affection of the larynx—the Laryngismus Stridulus of Dr Mason Good; and from Diphtheria (q.v.), an infectious disease in which a false membrane is usually found on the pharynx or palate, as well as in the larynx. As croup is an acute and very fatal disease, the treatment requires to be active and decided. If the case is seen early, apply an ice-bag to the throat and give ice to suck, but if you suspect the presence of false membrane, give a full dose of an emetic, such as ipecacuanha, sulphate of copper, or sulphate of zinc, which should be repeated in three or four hours if necessary and effectual in relieving the breathing. The child should at intervals be placed in the hot bath, and inhalations of steam or medicated vapours administered. An inhalation of lactic acid is often of great use in the first stage. If these means fail, Tracheotomy (q.v.) must be at once resorted to, to save the life of the patient, as recommended by Trousseau.

Crucibles (Low Lat. *crucibulum*; from the root of Old Fr. *cruche*, 'a pot') are vessels made of materials capable of being exposed to high temperatures without alteration, and used for fusing substances together, such as the materials for glass-making, or metallic ores, with various fluxes to obtain the several metals they yield. Crucibles should resist the corrosive action of the substances brought into contact with them, and are generally made of fireclay, porcelain, graphite, iron, platinum, and, for some special operations, of silver. See ASSAYING.



Crucible.

Crystallography (from the Greek *krustallos*, 'ice,' an idea among the ancients being that rock-crystal, which may be taken as a type of crystalline minerals, resulted from the subjection of water to intense cold). Minerals, salts, and inorganic bodies generally (examples, rock-crystal, fluor-spar, alum, and sugar) exist in the crystalline state; and when we examine all crystals, whether occurring naturally or obtained artificially, certain laws have been discovered, and phenomena observed, and these laws and phenomena constitute the science of crystallography. The following are the more important laws and principles of the science:

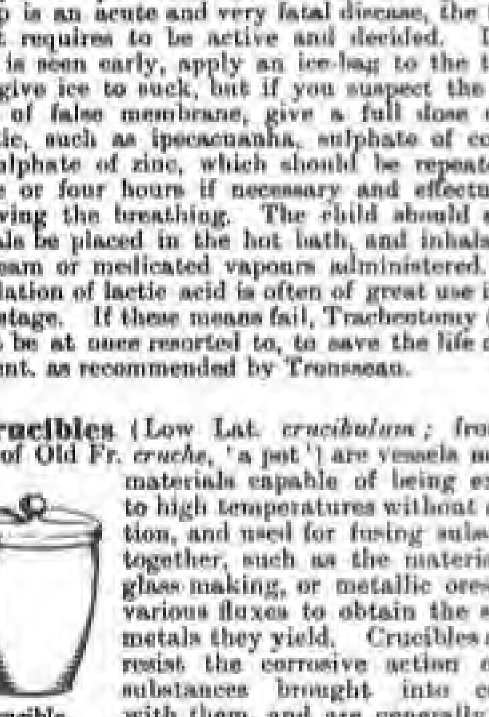


Fig. 1.
Drawings of two crystals differing much in appearance, but with angles at *a* shown to be constant when similar sections are made.

(1) *Law of Constancy of Angles.*—Crystals of the same substance may differ much in general appearance, but when the angles between their faces are measured these angles are found constant. Thus the crystals A and B (fig. 1), when cut through in the direction *xy* at right angles to the prism, give the sections shown at A', B'; and in each section the angles *a* will be found the same—viz. 120°; or again, if the angles between the faces *ab*, *bc*, or *ac*, be measured, they will be found identical in both crystals.

(2) *Law of Symmetry.*—Suppose we cut a crystal in two, and then place the two parts with their cut surfaces on a mirror. The mirror will reflect each part, and may or may not produce the appearance of the original crystal. If the mirror will produce the appearance of the original crystal, we have severed the crystal in a plane of symmetry. Thus with a cube, if we cut it in either of the planes *abc*, *def*, *ghk*, *lmn*, *opq*, *rhm*, *nkg*, *lkn*, *gmk*, and place in each case the two severed parts on a mirror in the way described, the reflection together with the object will reproduce a cube. There are then in the cube nine planes of symmetry. The octahedron and dodecahedron similarly have nine planes of symmetry. With such a form as a common brick there are three planes of symmetry, while with other forms varying numbers of planes of symmetry may be found, until with a sphere there are an infinite number of planes of symmetry, for it is obvious that if a sphere be cut anywhere by a plane passing through its centre, and the half thus obtained be laid upon a mirror, the appearance of a complete sphere will be produced. Now examining all (holohedral) crystals, it is found that they fall into one of the following six categories or systems: (1) *Anorthic System.*—No plane of symmetry—examples, copper sulphate and anorthite. (2) *Oblique System.*—One plane of symmetry—gypsum and washing-soda. (3) *Prismatic System.*—Three planes of symmetry at right angles to each other—barytes, saltpetre, and native sulphur. (4) *Rhombohedral System.*—Three planes of symmetry at 120° to each other—calcite, quartz, and ice. (5) *Pyramidal System.*—Five planes of symmetry—cassiterite, zircon, and idocrase. (6) *Cubic System.*—Nine planes of symmetry—fluor-spar, galena, and alum.

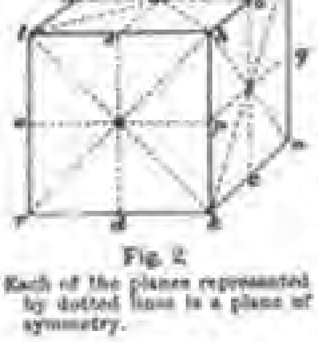


Fig. 2.
Each of the planes represented by dotted lines is a plane of symmetry.

(3) *Law of Rationality of Indices.*—The various planes of crystals, as explained below, are indicated in the Millerian system by three numbers, which together form the symbol of the plane. Thus we have planes represented by 1 2 3, by 1 1 1, by 1 1 0, &c. Now the law of rationality asserts that the symbol of a plane must be represented by numbers which are rational—i.e. numbers which can be expressed exactly, not those like $\sqrt{2}$, $\sqrt[3]{4}$, &c., which can only be obtained approximately. Thus by the law of rationality, no plane of a crystal can have such a symbol as 1 $\sqrt{3}$ 5, 1 $\sqrt{2}$ 0, &c.

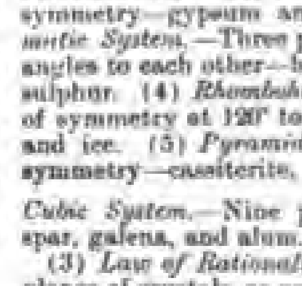


Fig. 3.
The plane 1 1 1 in Miller's notation.

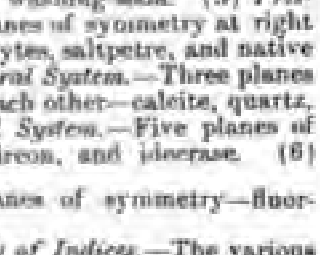


Fig. 4.
The plane 1 2 3 in Miller's notation.

Crystallographic Notation.—Several methods of representing planes of crystals by symbols are in use. Two of these only need be mentioned—viz. Miller's notation and Naumann's notation. In both systems the planes are referred to three axes corresponding in direction to three edges of the crystal.

Let *abc* (fig. 3) represent parts or parameters cut off from three axes *xyz*, then in Miller's system the plane 1 1 1 represents a plane which cuts the *x* axis at one-oneth of *a*, the *y* axis at one-oneth of *b*, and the *z* axis at one-oneth of *c*. Such a plane is indicated by *pqr*. The plane 1 2 3 means a plane which cuts the *x* axis at one-oneth of *a*, the *y* axis at one-half of *b*, and the *z* axis at one-third of *c*. Such a plane is represented by *stu*, fig. 4. The plane 1 1 0 means a plane which cuts the *x* axis at one-oneth of *a*, the *y* axis at one-oneth of *b*, and the *z* axis at one-noughth of *c*—i.e. does not cut *c* at all, or is parallel to it. Such a plane is represented by *uvws* in fig. 5.

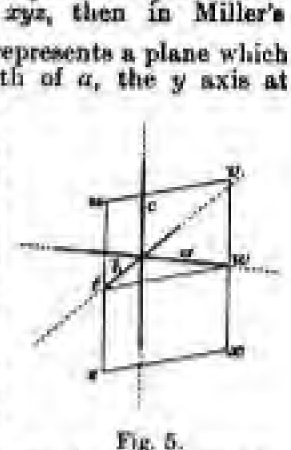


Fig. 5.
The plane 1 1 0 in Miller's notation.

In Naumann's system some form is selected as the fundamental pyramid of the crystal, and his pyramid, which corresponds to Miller's form, 1 1 1, is represented by the letter P in all systems but the cubic (in this system it is called O) and the rhombohedral (in this system it is called R). Thus the planes marked P (fig. 6) form the fundamental pyramid, the planes ½P are those of a pyramid one-half the height, while the basal plane is represented by oP or a pyramid of no height, while the planes ∞ P represent a pyramid of infinite height.

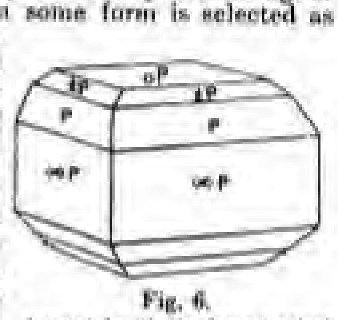


Fig. 6.
A crystal with the faces marked in Naumann's notation.

Drawing and Mapping of Crystals.—Various modes of representing crystals have been adopted. Perspective drawings are made by projecting the axes according to the rules of Projection (q.v.), then the various planes are indicated, and from these their intersections are known, and these intersections form the drawing of the crystal. Fig. 7 represents one octant of the form 2 1 1 drawn by this method. Some writers represent crystal forms by orthographic projections—that is, represent them in plan and front elevation. Of all methods, however, of representing crystals from measurements made with the goniometer, the most elegant and convenient is that of spherical projections. Two kinds of spherical projection are in use—viz. the *gnomic* and the *stereographic*. Imagine a glass sphere placed within a crystal, as in fig. 8, and suppose the faces of the crystal to move parallel to their original positions until they touch the

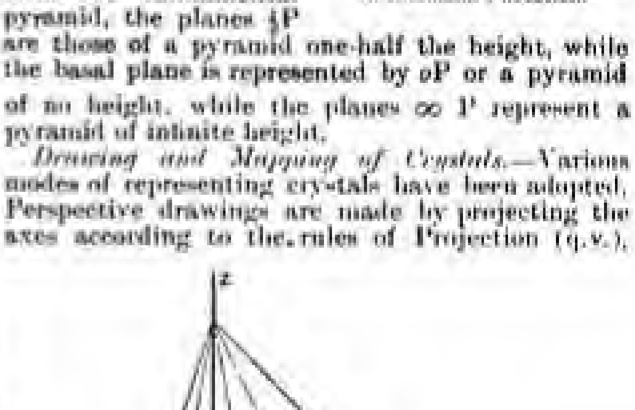


Fig. 7.
Mode of drawing a crystal from projection of axes.

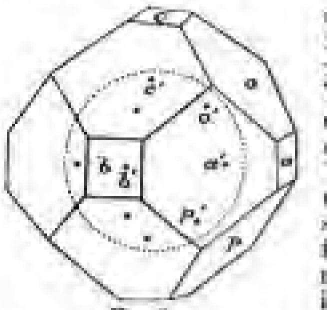


Fig. 8.
Sphere within a crystal. When planes are moved they touch the sphere where dots are marked.

sphere, and where the faces touch let dots be marked on the sphere. Thus the face *a* will produce the dot *a'*, the face *o* the dot *o'*, and so on. When the sphere is thus marked with dots corresponding to the several faces, the next thing is to make a map of the dots in their proper position. If the map is to be made on the gnomic projection, the sphere is supposed to be placed on the paper on which the map is to be made, and the eye is then placed at the centre of the sphere. The various dots when projected on to the paper as seen by the eye placed at the centre of the sphere produce the map. If the map is to be made on the stereographic projection, suppose a piece of glass to pass through the centre of the sphere as in fig. 9, and let the eye be placed touching the sphere at E, then the dots as they appear on the glass to the eye at E form the map. Such a map of the crystal of fig. 8 is given in fig. 10. In the stereographic projection all great circles on a sphere are represented on the map by either straight lines or arcs of circles, whereas in the gnomic projection they are represented by straight lines. The map (fig. 10) shows not only the position of the dots or poles, but also great circles passing through the sphere. These great circles correspond to the planes of symmetry of the cube (fig. 2) and other forms of the cubic system. These stereographic maps, as will be seen by reference to treatises on

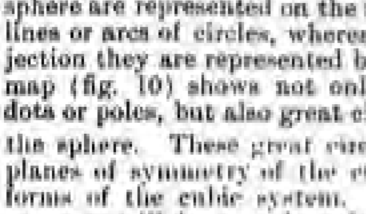


Fig. 9.
The eye placed at E sees the dots on lower part of sphere projected on the plane *a b c d*.

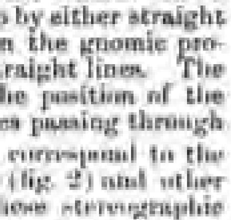


Fig. 10.
Stereographic map of the crystal of fig. 8 as obtained by method in fig. 9.

the subject, convey a good deal of information respecting the crystals they portray.

Planes of crystals form a *zone* when the intersections of the planes (i.e. the edges) are parallel to each other. Thus, in fig. 6 the faces oP, ½P, P, and ∞P form a zone. Now in Miller's notation these forms have the indices 0 0 1, 1 1 2, 1 1 1, 1 1 0, and it will be noticed that all these symbols have a common ratio—thus, the first and second index are equal to each other. It may be shown that this is universally true; hence, knowing the indices of a plane, we can say whether it is on a particular zone, or knowing that a plane lies in two zones, we can determine its indices. Thus, the planes 1 2 3, 1 2 4, 1 2 5, &c., are all in one zone, as the symbols have the common ratio 1 : 2, and the plane 3 4 5 cannot be on this zone, because its symbol does not contain the ratio 1 : 2.

Holohedrism and Hemihedrism.—Crystals which have all faces present as required by the law of symmetry are termed holohedral. Where, as is often the case, only one-half of these faces are present, the crystal is said to be hemihedral; while if only one-fourth of the full number of faces are present, the crystal is said to be tetartohedral.

Physical Crystallography.—The physical properties of crystals have some interesting relations to the symmetry and form of the crystal, and these properties are included generally with crystallography. Thus, if in the regular system a face is striated or has any peculiarity, this striation or peculiarity will be found on each face which is present by the law of symmetry. Again, most crystals cleave (i.e. break easily) in certain directions, and the cleavage planes follow the law of symmetry. Again, when examined by polarised light, other properties of crystals in relation to symmetry are brought out. Thus, crystals of the regular system (except in a few certain cases) do not doubly refract light, no matter in what direction the light is incident. With crystals of the rhombohedral system and the pyramidal system light is not doubly refracted when it falls parallel to the vertical axis, but in other directions it is doubly refracted; while in the remaining systems two directions can be found in which the crystals of these systems do not doubly refract light, though they do so in all other directions. Again, heat is conducted differently in different systems of crystals. Suppose crystals turned in a lathe into spheres, and that the centre is made suddenly hot, then in the regular system the heat spreads equally, and after a time the surface of the sphere is uniformly raised in temperature; with other systems the effect is different; with the pyramidal and rhombohedral systems a similar experiment would result in the surface of the sphere being heated uniformly over belts corresponding to an equator and parallels of latitude, but the temperature of the different belts would be different, thus showing that heat is propagated in two directions at right angles to each other with different velocities. With other systems more complex results would be obtained owing to heat being propagated in three directions with different velocities.

When soluble crystals are placed in a solvent the faces are eaten out differently, producing figures termed by German writers 'aetzfiguren.' These figures will often indicate the symmetry of the crystal, and have been useful in such determination. As physical properties generally are related to elasticity, Groth states that the best way to define a crystal is that it is a solid body, the elasticity of which is the same in all parallel directions, but on the contrary is different in different directions.

Crystalloid is a name given by Graham to a class of substances which when in solution pass easily through membranes; as opposed to *colloids*. Metallic salts, sugar, oxalic acid, are crystalloids.

Cubebs, or CUBEB PEPPER, the dried berries of *Piper Cubeba*, a climbing shrub, a native of Sumatra, Java, and Southern Borneo. The berries are about ¼th of an inch in diameter, and are furnished with a thin stalk a little longer than the berry itself. The fruits of other species of Piper are sometimes substituted for the true cubeb, such as those of *Piper longum*, &c., but in general the stalks of these substitutes are either wanting or are less than the length of the berry. Although known to the Arabs in the middle ages, and used in medicine as well as in culinary art, cubebs fell gradually into disuse, till at the beginning of this century all reference to it was omitted in medical books, and its importation into Britain ceased entirely. It is again, however, coming into use. As a stomachic and carminative in indigestion it has a certain value, while in piles and in sore throats its administration is attended with benefit.

Cubebs contains a volatile oil, a crystalline substance called *cubebin*, and resinous bodies, one of which is *cubebic acid*. The cubebin is inactive, while the volatile oil is not believed to have the full virtue of the cubebs. It enters, however, into the composition of a well-known voice lozenge, to which it imparts highly stimulating properties. The diuretic properties are held by some to be entirely due to the resinous bodies, but on this point there is difference of opinion. The dose of powdered cubebs is from one to three drachms, that of the volatile oil ten drops, and of the oleoresin five to thirty drops.

Cudbear. The lichens from which, and the process by which, this dyestuff is obtained, are described under the head ARCHIL, cudbear being simply archil paste dried and ground. It is very useful to the wool-dyer for producing, in conjunction with indigo, logwood, fustic, and other colouring materials, rich shades of brown and chocolate. The preparation of archil, known as French purple, was used for a short time in calico-printing, and produced fine and delicate shades of purple, but its employment for this purpose ceased soon after the introduction of aniline mauve as a dyestuff. The ancient Cretan purple was probably obtained from the same source as archil. The name cudbear is a corruption of *Cuthbert*, and is derived from that of Dr Cuthbert Gordon, under whose management the manufacture of this dyestuff was begun in Leith about the year 1777, by Mr Macintosh of Glasgow.

Cudweed, the popular name of many small inconspicuous species of composite weeds of the genera Gnaphalium, Filago, and Antennaria, the stems and leaves of which are more or less covered with a whitish cottony down. The heads of the flowers consist, in great part, of dry involucral scales, and may be kept for a long time without undergoing much apparent change, so that they may be reckoned among *Everlasting Flowers* (q.v.). *Antennaria dioica* (also called Cat's-foot) is very frequent in dry mountain-pastures. All the three genera are represented in the United States, where *Gnaphalium polycephalum* has some repute in domestic medicine.

Culm, a kind of impure Anthracite (q.v.). In some districts the culm obtained from the pits in a broken and crumbling condition is used as fuel, being made up into balls, with one-third of its bulk of wet viscid clay. It burns without flame, producing a strong and steady heat, well adapted for cooking (see BRIQUETTES). The term *Culm-measures* is applied to the carboniferous strata of Devonshire, on account of the workings for culm near Bideford, and other places.

Curari, URARI, WOORALI, or WOORARA, is a celebrated poison used by some tribes of South American Indians for poisoning their arrows. It is by means of this poison that the small arrows shot from the Blowpipe (q.v.) become so deadly. It is brought to Europe as a black, brittle extract, resinous in appearance, and encrusting the sides of little gourds containing it. The source of this deadly poison was for long unknown, owing to the natives jealously guarding the secret. The process of manufacture has now, however, been witnessed and described by several travellers, and in each case some species or other of Strychnos has been recognised as the source of the poison. There seem to be four distinct varieties of curari, each characteristic of a different tract of country, and probably varying in their physiological action; but for our purpose we may confine ourselves to that kind which is used in physiological experiments. Curari is one of those poisons which have little action when taken into the stomach, owing to the difficulty with which they are absorbed, but when introduced into a wound it acts with great promptness. The symptoms caused are loss of muscular power, feeble respiration, and death by suffocation. By means of artificial respiration it is possible to sustain life for a lengthened period, although the animal is apparently insensible to pain. In this way it is employed in vivisection experiments as an anæsthetic.

At first it was supposed that curari contained strychnine, but as its action was so entirely different, this view was soon abandoned. Prolonged research has separated a special alkaloid, *Curarine*, which possesses the leading properties of the poison itself. *Curarine* differs from all other crystallisable alkaloids, save one, in containing no oxygen. It forms salts, and is said to be twenty times as strong as curari. In medicine curari is very little used. It has been proposed to employ it in lockjaw, hydrophobia, and as an antidote in poisoning by strychnia; but although it quiets the spasm, it has no direct curative effect, and it may cause an equally fatal paralysis.

Besides curari proper, there are two other arrow-poisons called Corroval and Vao. These, which are brought from New Granada, have an entirely different action on the body, as they primarily stop the beating of the heart, whereas with curari the heart continues to beat after breathing has ceased.

Currant Wine is made of the juice of red or white currants, to which is added about one pint of water for every four pints of berries employed. About a pound and a half of sugar is afterwards added to each pint of the liquor, a little spirits being generally also added, before it is set aside to ferment. A larger quantity of sugar is sometimes employed, and no water, and a stronger and sweeter currant wine is thus produced. Fermentation requires several weeks, and the wine is not fit for use for at least some months afterwards. Black currant wine is made in the same way from black currants, but the fruit is put on the fire in as small a quantity of water as possible, and heated to the boiling-point before it is bruised.

Curry Powder, or CURRY PASTE, is a compound of turmeric, coriander, pepper, ginger, and various spices; it is used to a large extent in India and elsewhere as a seasoning for a variety of dishes.

Cuticle, a sheath formed outside a layer of cells, either by their secretory activity or by a modification of their external portions. In the strict sense, a cuticle is not in itself cellular, but consists of the products or of the modified portions of underlying cells. The thin envelope which may be readily stripped off a leech or earthworm when killed in spirit supplies a convenient example. A cuticle is usually formed outside relatively passive cells, but even ciliated Epithelium (q.v.) may have its cuticular outer layer through the pores of which the cilia emerge. By continuous modifications of the cells considerable thickness of cuticle may be developed—as e.g. the hard lining of the gizzard in many birds. By chemical modification of a well-developed cuticular formation very varied protective and offensive skin-structures often result. Thus the peculiar gelatinous, cellulose-containing tunic of Ascidians is for the most part a cuticle; the shells of molluscs are cuticular formations plus lime; the raspers of snails are formed from cuticle; the hard armour of Arthropods is a cuticle associated with the formation of Chitin (q.v.); the bristles, jaws, and firm sheaths of many worms are also cuticular, and so on. For the use of the term in special connections—e.g. the cuticle of the hair or of the teeth, see special articles. The term must not be confused with *cutis*, one of the names for the under skin or *dermis*; nor should it ever be used as equivalent to skin.

Cuttings are branches or portions of branches of trees or shrubs, employed to produce new plants, by burying the lower end in the earth so that new roots may arise from the nodes. Nothing is more easy than to propagate willows, fuchsias, pinks, geraniums, currants, gooseberries, &c. in this way; but many other plants, commonly propagated by cuttings, require greater attention on the part of the gardener, warmth, a uniform damp atmosphere, and shade. The term cutting is, however, usefully extended by most horticultural writers to any part of a plant which can be separated to become an individual similar to its parent; thus some plants may be propagated most readily from simple leaves or portions of leaves, others from a segment of stem bearing a single leaf with a bud at its base, others from offshoots at the base of the parent plant, some again from the younger shoots, and others from partially ripened wood, and so on. Hence there is room for considerable experience and skill, and detailed instructions should be sought by the amateur florist in works on horticulture (e.g. Johnson's *Dictionary of Gardening*). The most convenient general method, however, is to strike cuttings in well-drained shallow pots or boxes of silver sand overlying a little sandy peat or loam; shade and water being applied with discretion, and bottom heat only in special cases, which of course include the majority of stove plants. Hardy fruit-trees may be best propagated by cuttings taken after the fall of the leaf, and planted on the north side of a wall, but not so close as to be constantly in shade.

Cyanogen, CN or Cy, although intrinsically of little importance, is one of the most interesting compounds of carbon. It was the first known compound body which was proved to be able to unite with elements in the same way as these substances unite with each other. Thus hydrogen, H, unites with chlorine, Cl, to form hydrochloric acid, and sodium, Na, unites with chlorine to form chloride of sodium, NaCl. Like these elements, H, Cl, or Na, each a single substance, the group CN, consisting of 12 parts of carbon and 14 of nitrogen, enters into combination, acting as if it also were for the time being an element; thus it forms cyanide of sodium, NaCN, or NaCy, and hydrocyanic acid, HCN, or HCy. There are now many thousands of such *radicles* known, of which the groups methyl, CH_3, ethyl, C_2H_5, &c. may be taken as other examples.

Cyanogen is a colourless, poisonous gas, which burns with a purplish flame. It is soluble in water, and can be condensed to a liquid, under a pressure of about four atmospheres (60 lb. per sq. inch). It may be obtained by heating the cyanide of mercury, $HgCy_2$, when the cyanogen passes off in the gaseous state.

Cyanogen forms poisonous compounds with metals called *cyanides*, of which the best known is the *cyanide of potassium*, a salt of much importance in photography. With hydrogen it forms the deadly prussic or hydrocyanic acid, while it is united with oxygen in cyanic acid. For the properties of *cyanides*, see HYDROCYANIC ACID.

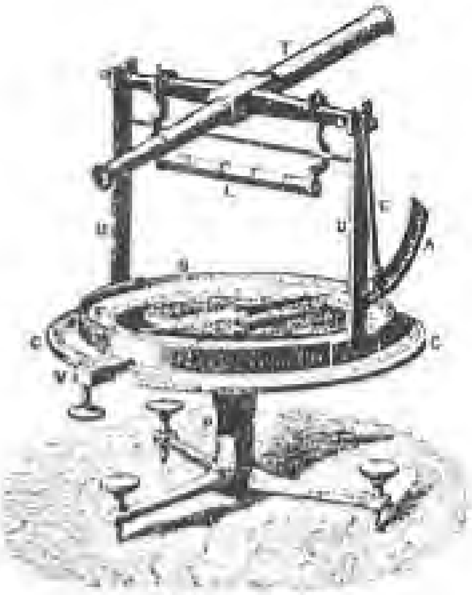
Cyanic Acid is a compound of cyanogen which can hardly be prepared in the free state, owing to its great tendency to decompose. It forms a class of salts called *cyanates*, of which the chief is the cyanate of potash. This salt is produced when cyanogen gas is passed into solution of potash. The formula of cyanic acid is HCyO, that of the potash salt being KCyO.

Cystin, or CYSTIC OXIDE, forms a rare variety of urinary Calculus (q.v.). Its chemical composition is $C_3H_7NSO_2$, and it forms a whitish or dirty yellow deposit consisting of six-sided crystalline tablets. It is soluble in ammonia, and is thereby distinguished from the similar crystals of uric acid.

Damascening, or DAMASKENING, is a name which is given (1) to the watered or striated structure seen in certain sword-blades and other weapons, and (2) to the ornamental incrustation with gold and silver of steel and iron surfaces. The term in both its applications originates from the city of Damascus, whence the crusaders brought into Europe swords and other weapons of remarkable strength, elasticity, and keenness of edge, the surfaces of which were beautifully striated with waved dark and light lines. The hilts of such weapons, and the whole surface of defensive armour from the same source were in many cases elaborately ornamented with incrusted gold, and hence one term came to be applied to the peculiar structure of the metal, and to its ornamental treatment. It is probable that even in the crusaders' times the making of the so-called Damascus blades and the art of damascening were Persian, and to this day they remain characteristic of that country, the practice having spread thence eastward into India, while the Persians still supply the Turks on the west with their best and most highly ornamented weapons. The production of a watered or damascened surface is illustrated by the manufacture of 'Damascus twist' barrels for sporting-guns. The metal for the barrels is prepared from rods of iron and steel, piled alternately and forged and welded together into a single solid rod of small section. Three of these composite rods are used in forming a barrel. They are separately twisted in contrary directions till each has the appearance of a fine threaded screw, then they are welded together into a solid ribbon, which in its turn is spirally wound and welded by the edges till the requisite length and bore of barrel are formed. The result of the intertwisting of fine laminæ of steel and iron is a beautifully damascened surface which shows itself when the barrel has been treated with acid. The incrustation of arms, armour, and other objects of steel and iron with gold, and more rarely with silver, is very extensively practised in the North-west Provinces of India, as well as in Persia. In India it is known as Kuft work or Kuftgari. The design to be worked out is undercut in the metal, into this the gold or silver wire is laid, and the scarp edge is beaten down with a hammer, thus securing the wire in its position. Another method consists in scratching the surface, and beating into the scratched lines the gold or silver wire, after which the whole surface is burnished to remove the incisions.

Damping off, in Horticulture, the death of plants from excess of moisture in the soil and atmosphere. Young seedlings in stoves and hot-beds are particularly liable to it. Although the cause is sufficiently obvious, prevention is not always easy; not only because some plants are very sensitive as to moisture, but also because the necessity of keeping sashes closed on account of temperature often stands in the way of the ventilation which would otherwise be desirable, and it is when a moist atmosphere stagnates around them, and the temperature is not very low, that plants are most liable to damp off.

Declination Needle, or DECLINOMETER. The magnetic meridian passing through any place on the earth's surface is a vertical plane whose direction is that in which a magnetic needle, free to move about a vertical axis, comes to rest under the influence of the earth's magnetic force. In general, the magnetic and geographical (or astronomical) meridians are not coincident; the angle between is termed the magnetic declination, or



Declination Needle.

(in nautical phraseology) the variation. It is east or west, according as the magnetic is east or west of the geographical meridian. Any apparatus for the measurement of this angle is termed a declinometer, and consists essentially of a means of ascertaining the two necessary elements—viz. the directions, at the place of observation, of the two meridians. The accompanying figure represents one such instrument, the declination needle or compass. Upon a tripod, provided with levelling screws, stands the pillar P, to which is fixed the graduated circle CC. The compass-box B, with the attached vernier V, moves on the azimuthal circle by means of a pivot on the pillar P. Two uprights, U,U, are fixed to the side of the compass-box, on the tops of which rests the axis of the telescope T. A graduated arc, A, is fixed to the bottom of one of the uprights, and the angle of elevation of the telescope is marked by the vernier on the arm E, attached to the axis of the telescope, on which is hung the level L, for adjusting the instrument previous to making an observation. Inside the compass-box is another graduated circle F, the line joining the zero-points of which is parallel to the axis of the telescope. The compass-box and telescope thus move round together on an axis passing through the centre of the azimuthal circle. When an observation is made, the instrument is first of all levelled, and the telescope directed to a star which is either on the astronomical meridian or whose position with respect to it is known. The reading of the inner circle then gives the declination at once, in the former case; if the latter—i.e. if the star be not on the meridian, the reading of the inner circle has to be corrected by adding or subtracting, as the case may be, the position of the star in azimuth, in order to give the declination. In order to obviate error due to the non-coincidence of the magnetic and geometric axes of the needle, a second reading is taken with the face of the needle reversed; the mean of the two readings is taken as the true declination.

It is found, however, that this instrument only gives results approximately correct, and has in consequence been superseded in observatories and magnetic surveys by a form of the unifilar magnetometer. For an account of the determination of declination by this latter instrument, see MAGNETOMETER. Details as to the value and secular change of the declination at different places on the earth's surface will be found under MAGNETISM.

Decoction, the term applied in pharmacy to the solution procured by boiling an organic substance with water.

Decolorim'eter, an instrument for determining the power of portions of bone-black or animal charcoal to abstract colouring matter. See CHARCOAL.

Decomposition is the rather comprehensive term applied to the breaking up of complex substances, or substances of delicate stability, into others which are less complex or more stable. Such breaking up is very familiar in many chemical changes, and may result from increase of temperature, the action of light, the action of ferments and micro-organisms, and so on. The ordinary process of alcoholic fermentation is a good example of decomposition, which takes place in the presence of, and is dependent upon, the life and growth of yeast in the saccharine solution. Similarly the oxidation of nitrogenous organic matters with formation of nitrates, if not dependent upon, is greatly accelerated by the presence of a micro-organism.

The term decomposition is constantly applied in chemistry to the changes which compounds undergo in the most varied circumstances when subjected to change of conditions. See also CHEMISTRY, FERMENTATION, PUTREFACTION.

Deflagration is the term applied to the rapid combustion of ignited charcoal when a nitrate (such as nitrate of potash) or a chlorate (such as chlorate of potash) is thrown thereon. As chlorates do not occur naturally, it follows that deflagration with a natural salt indicates a nitrate; and if the deflagration be accompanied by a violet flame, it is characteristic of nitrate of potash (ordinary nitre or saltpetre); and if by a strong yellow flame, it is indicative of nitrate of soda (cubical nitre).

Deliquescence is the term applied to the property which certain substances have of absorbing moisture from the air, and becoming damp, and even running into liquid. Caustic potash, and the chlorides of calcium and magnesium, are examples of substances which undergo this change.

Delirium is a condition in which there is perversion of the mental processes. In its essential nature this symptom is analogous to insanity; insanity is, in short, a similar state, unaccompanied by the obvious conditions which are the causes of delirium.

In health the mental processes correspond to present sensory impressions or to the memory of those which are past, but in delirium this correspondence ceases, and the results of cerebral activity bear no true relation to reality. Delirium has three well-known mental phenomena, any or all of which may be present in any individual instance. The mind may be possessed by false ideas or *delusions*; sensory impressions may produce false perceptions or *illusions*; or there may be fictitious perceptions or *hallucinations*, without the presence of any sensory impressions.

The more common causes of delirium are four. (1) Local diseases of the brain or its envelopes, as in the case of inflammation of the lining membranes. (2) Toxic substances circulating in the blood, which may have their origin within the system, as in the retention of waste products during the final stages of kidney disease, or may be introduced from without, such as the specific poisons of the acute infectious diseases, or active substances like alcohol. (3) High body temperatures, which may occur apart from any blood-poison in a local inflammation of some distant organ. (4) Inanition, which may often be seen in the concluding periods of wasting diseases.

Delirium Tremens is the term employed to denote one of the acute phases arising in the course of chronic Alcoholism (q.v.). It is as a rule precipitated by a period of indulgence in excessive drinking, and shows itself at first in the form of general uneasiness and restlessness during the day, followed by sleeplessness, or disturbed sleep with distressing dreams, at night. These initial symptoms usher in the stage of delirium, always accompanied by constant muscular tremors. The delirium almost invariably presents the three main varieties of mental disturbance—illusions, hallucinations, and delusions—to which reference has been made in the preceding article. An attack generally lasts about three days, but it may exist for a period of six or seven days, and, so far as is at present known, there is no means of shortening its duration. The chief danger lies in the great tendency to exhaustion which the disease shows. One attack appears to have a power of predisposing the individual who has suffered from it to subsequent recurrence. The affection frequently induces some degree of mental weakness, and this is more likely to be the case in those who belong to families which have a hereditary tendency to insanity. As above mentioned, no means is known of cutting short an attack, and the employment of drugs in this disease is of at least doubtful utility. The only rational treatment consists in the use of every expedient which can tend to sustain the patient, and avert the great tendency to exhaustion of the vital centres.

Demand and Supply. In Political Economy demand has reference to the quantity of goods asked for in the market, and supply has reference to the quantity of goods offered. The laws of demand and supply may be thus stated: when the demand exceeds the supply, competition grows stronger among the buyers, and prices rise, and when the demand falls short of the supply, competition grows stronger among the sellers, and prices fall; or thus, falling prices tend to lessen the supply and increase the demand, while rising prices tend to increase the supply and lessen the demand. A rise in prices tends to encourage production, while a fall in prices tends to discourage it. Conversely, consumption is promoted by falling and lessened by rising prices. The result is that demand and supply continually tend to equilibrium. Under such a system it is assumed that buyers and sellers or producers and consumers are free to fix their own prices. In other words, the laws of supply and demand prevail under a system of free competition.

Demulcents (Lat. *demulceo*, 'I soften'), bland and lubricating liquid substances, taken by the mouth, for the purpose of soothing irritation of the mucous membranes, and promoting the dilution of the blood, and the increase of the secretions. Demulcents are chiefly composed of Starch (q.v.), or Gum (q.v.), or of substances containing these, dissolved in water; sometimes also of oily matters, or the white of eggs, and other albuminous or gelatinous substances largely diluted. The decoction of althæa, or marsh-mallow, is a favourite form of demulcent.

Dengue, or BREAK-BONE FEVER, also called DANDY and BUCKET FEVER, is a disease first certainly known to have occurred in 1779-80 in Egypt, parts of the East Indies, and probably in Philadelphia. Since that time there have been great epidemics in India and Further India (1824-25), America and West Indies (1826-28), Southern United States (1850), East Africa, Arabia, India, and China (1870-73), besides numerous minor outbreaks. The disease occurs almost exclusively in the tropics, in hot weather, and in towns either near the sea-coast or on large rivers. It is characterised by sudden onset, with high fever, and extremely violent pains in the bones, muscles, and joints; by a remission, usually at the end of one or two days, during which the patient feels almost well; and after one or two days more by a second period of fever, less severe than the first, which lasts for two or three days. Each attack of fever is often accompanied by a well-marked skin-eruption. Though often followed by much emaciation and loss of strength, it is very rarely fatal or succeeded by serious after-effects. It occurs almost always in well-marked epidemics; but observers are much divided upon the question whether it is communicable directly from the sick to the healthy. See Hirsch, *Geographical and Historical Pathology*, vol. i.

Deodorisers are chemical substances employed for the purpose of absorbing or destroying the odoriferous principles evolved especially from decomposing animal and vegetable matter. Thus, freshly burned charcoal is a powerful deodoriser because it absorbs sulphurous acid gas, ammonia, and other odorous gases. They belong to the classes of substances known as Antiseptics (q.v.) and Disinfectants (q.v.).

Deoxidation is the term applied to the process of withdrawing the oxygen from a compound, as in the reduction of the native peroxide of iron to the smelting-furnaces to the condition of metallic iron. On the small scale, in experimental inquiries, the process of deoxidation may be carried on before the Blowpipe (q.v.), where the inner or reducing flame is essentially a deoxidising one.

Dephlogisticated Air. See PHLOGISTON.

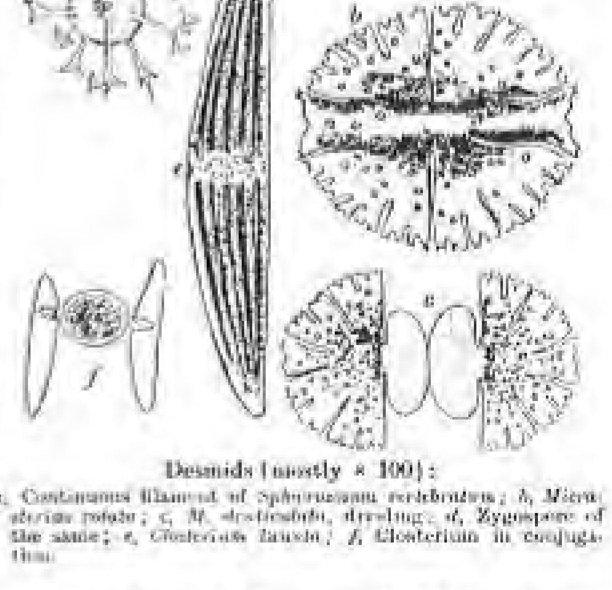
Depilatories (Lat. *depilo*, 'I pull out the hair') are chemical agents employed for removing superfluous hair from the skin. They were extensively used by the ancients, but are now restricted in their employment to the face, and to the removal of the hair from the scalp in the treatment of certain diseases. They should only be used under medical advice.

Desiccants, in Medicine, are substances with astringent properties, which are serviceable in checking secretion and exhalation.

Desiccation is the process of drying by the employment of heat, dry air, or chemical agents which have an affinity for water. Examples of the class of *desiccants* or drying substances are fused chloride of calcium, quicklime, fused carbonate of potash, and oil of vitriol. The latter is employed by being placed in a separate vessel near the substance to be dried, and under a bell jar.

Not a few of the lower animals are said to be able to endure drying up without losing the power of recovery. Some of the Protozoa form protective sheaths or cysts from which they emerge on the return of moisture. Nematodes or thread-worms (paste-eels) have been known to revive after fourteen years' desiccation, but trials beyond this limit were unsuccessful. With those animals the interesting fact has been noticed that the longer the period of desiccation, the longer the time required for recovery. Rotifers are also described as reviving after prolonged and thorough desiccation, but experiments have shown that, in the case in question at least, only the associated eggs retained their life. The eggs rapidly developed on the return of moisture, but the adult organisms proved to be really dead. The bear-animalcules or Tardigrades have been thoroughly desiccated and even heated to a high temperature without, it is said, losing power of revivification. A state of latent life is also assumed in consequence of cold, absence of stimulus, &c., and a relative quiescence occurs naturally in hibernation, or pathologically in trance. Among the lower plants, resting spores, &c., may survive desiccation; and, among the higher, seeds are well known to have a similar power.

Desmids (*Desmideæ*) are a group of conjugate Algæ (see ALGÆ) related to diatoms, but readily distinguished from these by their bright green instead of brownish-yellow colour, their cellulose instead of silicified walls, and their general form, which is usually more or less deeply constricted in the middle line. As with diatoms the lower forms are, however, united in long chains, so indicating a relationship to the lower and filamentous Conjugatæ (Spirogyra, &c.). About four hundred species have been described, but these are often variable and ill defined. All are inhabitants of fresh water, but chiefly occur in the standing pools of heaths and peat-mosses. They rarely form large aggregations; but usually occur associated with filamentous algæ, diatoms, and other forms of microscopic life. On account of the singular beauty of their general form they are much prized by the microscopist; their mode of division, too, is remarkable, yet akin to that of diatoms, the two halves of the cell being pressed apart at the median constriction



Desmids (mostly × 100):
a, Continuous filament of *Sphærozosma vertebratum*; *b*, *Micrasterias rotata*; *c*, *M. denticulata*, dividing; *d*, Zygospore of the same; *e*, *Closterium lunula*; *f*, Closterium in conjugation.

by the development of two new bud-halves to complete them (see fig.), two new desmids being thus gradually formed, which become as symmetrical as the original one, yet with the two apparently similar halves of very unequal age. Conjugation also occurs, with formation of a resting spore; the cyst of which may have peculiar markings or hook-like prominences.

Dextrine (syn. 'British gum,' 'torrefied starch'). When starch is carefully heated to 392° (200° C.), or until vapours arise from it, it becomes soluble in cold and hot water, and loses its gelatinous character; it also has the property, when viewed by polarised light, of turning the plane of polarisation to the right; hence its name. It is often used as a substitute for gum-arabic in the processes of calico-printing, and for stiffening different goods; it is also applied to the back of postage-stamps. Its value as a substitute for gum consists in its being more flexible and less brittle when dry than that substance. Starch may be converted into dextrine by the long-continued action of dilute acids at a high temperature; also by the action of Diastase (q.v.). Dextrine and starch are isomeric, both being composed of $C_6H_{10}O_5$; but dextrine may be distinguished from the latter body by its not being rendered blue by iodine, which gives with it a dingy purple tint.

Diabe'tes (Gr., lit. 'a syphon,' from *diabainō*, 'I go or flow through'), a disorder of the general system, of which the principal symptom is a greatly increased flow of urine. Diabetes is of two distinct kinds: the one, *diabetes insipidus*, is a mere exaggeration of the water-excreting function of the kidneys, accompanied by extreme thirst, and hence called *polydipsia* (Gr., 'excess of thirst') by some authorities; the other is a more complex disorder of the assimilation, consequent on the formation first, and the excretion by the kidneys afterwards, of an enormous excess of animal sugar (see SUGAR), the sugar being found in excess not only in the renal excretion, but in the blood, and in nearly all the secretions which have been examined. The pathology of this disease, called *diabetes mellitus* (Lat. *mel*, 'honey'), is very obscure, notwithstanding the numerous recent physiological researches which tend to throw light on the development of sugar in the animal organism, especially in the liver, and which must undoubtedly be regarded as bearing on the solution of the problems connected with this disease. Unhappily, the cure of it is still entirely unknown, except in so far as it may be controlled or retarded by good management of the diet, drink, and clothing. The course of the disease, however, is very different at different periods of life. Before middle age it is severe, progressive, and almost invariably fatal. After that period precisely similar symptoms often appear, especially in gouty persons, but are so much less dangerous, and so much more easily controlled, that many authorities are unwilling to place them in the same class as true diabetes. All diabetics are subject to progressive emaciation, and they often become subject to a chronic disease of the lungs, closely resembling true tubercular Consumption (q.v.); it is chiefly in warding off this termination, or some other more quickly fatal, and in mitigating the symptoms of the malady, that the medical art can be of service.

The first fact observed in cases of diabetes is usually the increased flow of urine, when it becomes so great as to amount to a practical inconvenience; and also a considerable increase of the appetite, and an unquenchable thirst, which rarely fail to accompany the disease from the beginning, but often do not attract attention, or at least suggest the idea of anything wrong, till an advanced stage of the disorder. When the patient demands medical assistance he is usually somewhat thin; the pulse is quiet, the skin cool, the heat of the surface, indeed, habitually rather low and easily depressed. There is often a complete absence of perspiration, which gives a peculiar feeling of harshness to the surface, especially of the palms of the hands. With these symptoms the first approaches of pulmonary disease may concur. In the very last stages there is sometimes dropsy of the feet; and the urine may be natural in quantity, or even diminished. For the other characters of diabetic urine, see URINE. Diabetic persons bear excitement and fatigue, either mental or bodily, extremely badly; and imprudence in this respect is not unfrequently followed by sudden or rapid collapse and death. The treatment consists mainly in removing from the diet, as far as consistent with comfort and due nourishment, everything which easily turns to the formation of animal sugar in the system, especially all excess of farinaceous food. The complete suppression of sugar-forming food, however, as recommended long ago by Rollo, has not been found possible in practice in the majority of cases. Bread composed of gluten of wheat without starch, or bran-cakes baked with eggs, or biscuits made of almonds, have been strongly recommended; and in most of the great capitals, as London and Paris, bakers may be found who regularly furnish bread suitable for this unfortunate class of sufferers; indeed, any intelligent baker who will take the trouble may, under medical direction, be got to manufacture such bread when required; or it may be ordered in the form of cakes and biscuits, in quantities at a time, from London houses. It is of importance, however, that it be ascertained that the bread or flour supplied is really suitable; for Dr Pavy, one of the chief authorities on this disease, ascertained that some of the so-called foods for diabetics contain little less starch than ordinary bread. Saccharin (q.v.) has lately been of great service to diabetics, as it supplies the flavour of sugar without its objectionable properties. Medicines proper should be used only under the advice of the physician. There is no specific, and the unguarded use of strong remedies is to be condemned. Of all medicines that have been used, however, opium and morphia have been found most frequently useful in delaying the progress of the disease. Flannel should be worn next the skin, and the languid function of the cutaneous perspiration aided by the warm bath, especially, perhaps, the vapour bath—e.g. that form known as the Russian bath. The Turkish bath, which abstracts a large quantity of water through the skin, is less suitable to such cases.

Diagnosis (Gr., from *dia*, 'through,' and *gnōsis*, 'knowledge'), in Medicine, the discrimination of diseases. It includes the study of all the vital phenomena of diseases, and also of their appearances after death, in so far as this can aid their discovery during the life of the patient. It is usual to speak of rational or physiological diagnosis, or diagnosis by symptoms—*i.e.* changes chiefly functional, observed by the patient; and of physical diagnosis, or diagnosis by signs—*i.e.* objective phenomena appreciable by the senses of the observer. The latter method of diagnosis has been much enlarged in scope and increased in importance by the modern methods in medicine of Auscultation (q.v.) and Percussion (q.v.), and also by the great advances made in physiological chemistry, and by the use of the microscope. Skill in diagnosis is one of the highest gifts of the physician, and nothing distinguishes the man of long experience from the tyro more than this unerring insight into some unseen disease.

Dial and **Dialling.** A *sun-dial* is an instrument for measuring time by means of the motion of the sun's shadow cast by a stile erected on its surface. It is an instrument of very great antiquity, and before clocks and watches became common, it was in general use as a time-keeper. Some old sun-dials are very elaborate—e.g. that at Glamis Castle, Forfarshire; and many bear quaint mottoes (cf. *Leisure Hour*, 1870, p. 413; and Mrs Gatty's *Book of Sun-Dials*, new ed. 1889). Dial-making was then an important branch of mathematical study; now it is more an object of curiosity than utility. A dial consists of two parts—the *stile* or gnomon, usually the edge of a plate of metal, always made parallel to the earth's axis, and pointing towards the north pole; and the *dial-plane*, which may be of any hard substance, and on which are marked the directions of the shadow for the several hours of the day, their halves, quarters, &c. Dials receive various names, according mostly to the positions which they are constructed to occupy. When the dial-plane is on the plane of the horizon, the dial is called a horizontal dial; when perpendicular to that plane, a vertical dial. An equinoctial dial is one whose plane is parallel to the equinoctial plane. The south dial, north dial, east dial, west dial, polar dial, declining dial, are named from the position of the dial-plane. The cylindrical dial is a dial drawn on the curved surface of a cylinder. The ring dial is an ingenious small portable dial, but rather a curious toy than a philosophical instrument. A *night* or *nocturnal dial* is an instrument for showing the hour of the night by the shadow of the moon or stars. Moon-dials may be constructed relative to the moon's motion; or the hour may be found by the moon's shadow on a sun-dial. But because of the irregularity of the moon's motion, due to its varying speed at different parts of its orbit, the time so found is subject to considerable error.

Dialling.—The *stile* of a dial being parallel to the earth's axis, those familiar with spherical trigonometry will readily see that the problem of constructing a dial resolves itself into that of ascertaining where the hour-lines cut a given circle, with a view to the graduation of the dial-plane. Suppose *Pep* (fig. 1), a hollow and transparent sphere, as of glass, to represent the earth; and suppose its equator divided into 24 equal parts by the meridians *a*, *b*, *c*, *d*, &c., one of them passing through a given place, say London (see HORIZON), at the point *a*. If the hour of twelve be marked at the equator, both on the latter meridian and that opposite it, and all the rest of the hours in order on the other meridians, those meridians will be the hour-circles of London, because, as the sun appears to move round the earth in 24 hours, he will pass from one meridian to another in one hour. Then, if the sphere has an opaque axis, as *Pep*, terminating in the poles P and *p*, the shadow of this axis would fall, in the course of the day, on every particular meridian and hour, as the sun came to the plane of the opposite meridian, and would thus show the time at London, and at all other places on the same meridian as London. If the sphere were cut through the middle by a plane ABCD, in the rational horizon of London, and if straight lines were drawn from the centre, E, of the plane to the points where its circumference is cut by the hour-circles of the sphere, these lines would be the hour-lines of a horizontal dial for London; for the shadow of the axis would fall upon each particular hour-line of the dial, when it fell upon the like hour-circle of the sphere. Similarly, if we suppose the

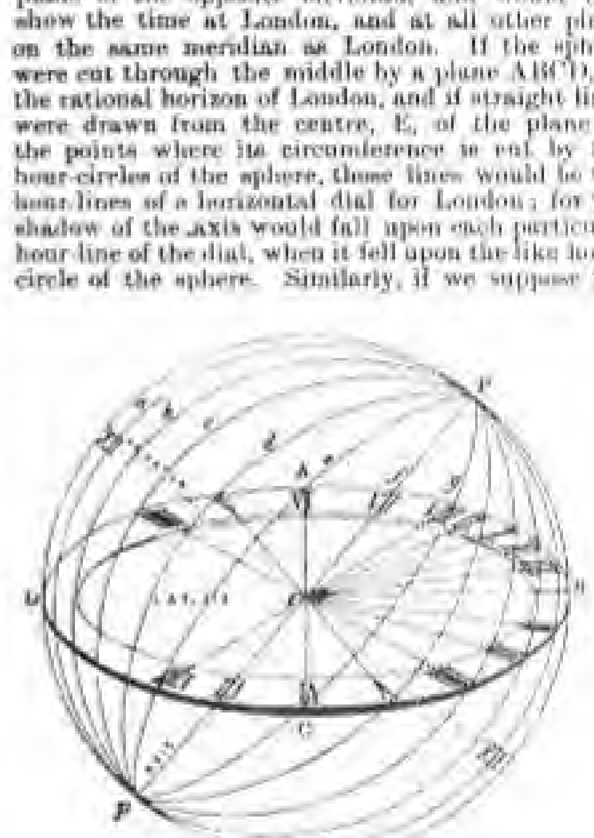


Fig. 1.

sphere cut by any other plane facing the meridian, the hour-circles of the sphere will cut the edge of the plane in those points to which the hour-lines must be drawn straight from the centre; and the axis of the sphere will cast a shadow on these lines at the respective hours. The like will hold of any plane, whether it face the meridian or not, provided it do not coincide with it, or do not coincide with a plane through the poles, and perpendicular to the plane of the equator. In the latter case, the axis

Fig. 2.

would have no elevation above the plane of the dial; in the former, the shadow would not move circularly.

The *universal dialling cylinder*, an invention of Ferguson's, is represented in fig. 2. ABCD is a glass cylindrical tube, closed at both ends with brass plates, on the centres of which a wire or axis, EFG, is fixed. The tube is either fixed to a horizontal board, H, at an angle equal to the latitude of the place, or moves on a joint, so that it may be elevated till its axis is parallel to the earth's at any latitude. The 24 hour-lines are drawn on the outside of the glass, equidistant from one another, and parallel to the axis. The XII next B stands for midnight; the XII next the board, for noon. When the axis is adjusted for the latitude, and the board levelled, with the line HN on the meridian, and the end towards the north, the axis EFG, when the sun shines, will serve as stile, and cast a shadow on the hour of the day among the parallel hour-lines. As the plate AD is parallel to the equator, and EFG perpendicular to it, right lines drawn from the centre to the extremities of the parallels will be the hour-lines of an equinoctial dial, and the axis will be the stile. A horizontal plate, *ge*, if put into the tube, with lines drawn from the centre to the several parallels cutting its edge, will be a horizontal dial for the given latitude; and similarly a vertical plate fronting the meridian, and touching the tube with its edge, with lines drawn from its centre to the parallels, will be a vertical south dial, the axis of the instrument in both cases serving for the stile; and similarly for any other plate placed in the cylinder. If, instead of being of glass, the cylinder were of wood, any of these dials might be obtained from it by simply cutting it in the planes of the plates, and drawing the lines on the surface of the section.

Dialling sometimes occurs as a term for surveying by help of a compass with sights, such as is called a 'miner's dial,' and is used especially in underground surveys and mine-surveying.

Diastase is a peculiar ferment developed during the germination of all seeds. An impure solution of diastase may be procured by adding one part of hot water to two parts of ground malt (see BEER), or freshly germinated barley, and, after standing for a short time, straining through a cloth. The proportion of diastase in malt is not more than 1 part in 500 parts, and yet it performs important functions. Thus diastase has a powerful action upon starch, and at a temperature of 150° F. one part is considered powerful enough to change 2000 parts of starch into dextrine, and then into maltose, a variety of sugar. When obtained separately, diastase is a white tasteless substance, soluble in water and in weak alcohol, and having no action on gum or sugar. A similar principle is found in the saliva of animals, the action of which on starch is identical with that of diastase. When bread is masticated, the saliva is rapidly secreted, and the animal diastase converts the starch into sugar.

Dia'thesis (Gr. *dia*, 'through,' and *tithēmi*, 'I place or arrange'), a Greek word signifying a disposition or arrangement, and applied by the old medical authors to the predisposition or constitution of the body which renders it prone to certain diseased states. By recent writers the term is applied to the general constitutional tendency of an individual, to indicate not merely the class of diseases to which he is most likely to be liable, but also in many cases the manner in which his normal functions, both bodily and mental, are carried on; and is thus opposed to Cachexia (q.v.), an unhealthy condition associated with actual disease. Though the study of diathesis apart from existing disease is very apt to lead to over-refinement and the pursuit of intangible abstractions, yet a proper appreciation of a person's constitutional proclivities or diathesis often enables a medical man to advise him how to regulate his life and habits to the best advantage—what to do and what to avoid—and may furnish important guidance as to his treatment in disease. The diatheses most usually recognised are the sanguine, the nervous or neurotic, the bilious, the lymphatic, the strumous, and the hæmorrhagic. Numerous mixed varieties are also described by some writers.

Diatoms (*Diatomaceæ*) are a group of algæ which, on account of their microscopic interest and geological importance, have acquired an unusual share of scientific and even popular attention. They were discovered by Leeuwenhoek in 1702, and their movements by O. F. Müller eighty years later; their thorough investigation, however, has only become possible with the development of the compound microscope.

The reader who wishes to view the diatoms other than as mere microscopic marvels must begin with a clear grasp of the structure and mode of life of the filamentous conjugate algæ, such as *Spirogyra*, and next observe that of those higher members of the group which we know as Desmids (see ALGÆ, DESMIDS). These simpler forms understood, let him next imagine a desmid (in which the characteristic division of the unicellular body into halves is distinctly but not too deeply marked) to become somewhat unequally developed; next let these be pressed together so that the larger half slides a little way over the smaller, much like the lid of a canister or the halves of a pill-box. Let the two halves or shells of the cell-wall now become strongly silicified, the cellulose only remaining unaltered and flexible round the narrow 'girdle band' connecting them; next let variation arise in the general shape so that the original box-shape becomes elliptical or wavy, squared, or more often pointed, or even unsymmetrically curved; finally, let the siliceous shells become covered with the most delicate striations and markings, and these characteristically varied, not only from group to group, but from species to species. A gelatinous envelope may also be developed, or this may be secreted at one pole only, forming a stalk.

The living protoplasm shows less variation than might perhaps have been expected; it lines the siliceous shell, leaving a large central sap-cavity, often traversed by protoplasmic filaments. Very commonly, however, this is divided by a large central mass of protoplasm usually containing the nucleus, while similar accumulations may be formed

Fig. 1. Fig. 2.

Pinnularia viridis: 1. *a*, Optical section through the unequal valves; *b*, side of one valve, showing markings and longitudinal slit.
2. Diagrammatic transverse section; *pp*, protoplasm containing endochrome-plates, *cc*; *g*, girdle band. Valves left unshaded, the left showing depressions due to markings.

at the ends. The colouring matter may occur in minute granules, or be collected into one or two large 'endochrome-plates;' it consists of chlorophyll, masked by a closely allied yellow pigment (*phycoxanthin*). Starch is absent; oil is frequently present, either in minute vacuoles or collected into a single large drop.

The mechanism of the peculiar creeping or rather gliding movements has long baffled investigators; these, however, are not due to diffusion currents as some have maintained, nor to the agency of any ordinary cilia or pseudopodia, but seem to be effected by means of a locomotor band of protoplasm which is said to be protruded through a longitudinal slit in the surface of the siliceous shells (see fig. 1).

The mode of multiplication is primarily by division, and is effected on the same principle as in Desmids (q.v.). Thus the two halves of the diatom are not only of unequal ages, but since the new half is always formed within the previous one, a continuous diminution of size takes place. At a certain limit, however, division stops, and rejuvenescence may occur, with formation of a resting spore; more frequently, however, this is preceded by conjugation as in desmids, though sometimes complete union may not take place. The resultant 'auxospore' has a continuous cellulose coat, but develops within it, by rejuvenescence, a two-shelled diatom of the largest size, which issues to divide in turn.

Of the 2000 species, 400 are fresh-water, the remainder marine. Their distribution is ubiquitous, and the genera and even species seem little dependent upon temperature or climate, many being apparently cosmopolite, and some having been described as occurring in glacier water, yet also in hot springs. Their minute size and resistance to drying favour their distribution in the form of dust: hence the calcination of the dust which falls upon ships in mid-ocean has been shown to yield an appreciable diatom residue. Every soil which is overflowed teems with them, notably, therefore, that of Egypt; harbour mud often contains one-fourth to one-half its volume of diatom shells, while in many parts of the world there occur strata of purely diatomaceous origin, which are frequently of vast area and considerable thickness. These are in all states of preservation and hardness, from the loose *Bergmehl* of Siberia and Lapland (which still contains so much undecomposed organic matter as to be mixed with flour in times of scarcity) to building stone, and even the extremely hard polishing slates of Tripoli. Diatomaceous deposits were found in Skye in 1886. The diatomite may be used for making dynamite, siliceous glazed paints, steam-pipe casings, &c. Diatoms live in enormous abundance at the surface of the sea in cold, temperate, and arctic latitudes, and the mud of the sea-bottom is hence very largely composed of the shells of dead diatoms, which are falling from the surface in a gentle but unceasing rain.

Die-sinking, the art of engraving the die or stamp used for striking the impression on coins and medals, and for stamping thin plates of metal into various shapes. The method of sinking the dies used for coins or medals will serve to illustrate the general method of die-sinking. Suppose the coin to be of the size of a shilling: a cylindrical piece of carefully selected steel, about three or four inches in length, and two in diameter, is prepared by slightly rounding one end of the cylinder, then turning and smoothing upon the middle of this a flat face equal to the size of the coin. This blank die, which is carefully softened by the process of Annealing (q.v.), is then engraved with the device of the coin in intaglio. This is a very delicate and artistic operation, and is effected by a great number of careful touches with small and very hard steel tools. The face of the die is now protected with a thin coating of lampblack and linseed-oil, and then placed with its face downwards in a crucible containing animal charcoal. In this position it is raised to a cherry-red heat, then taken out, and hardened by being plunged into water. When properly tempered, it is in a state to be used for stamping the coin; but dies of superior workmanship, from which many impressions are required, are not thus directly used, as the expense of engraving is very great, and the risk of breakage considerable. This first engraved die, called the matrix, is therefore reserved only for making other dies. An impression in relief is made from this matrix on a small block of soft steel, which is called the puncheon; this is retouched and hardened, and from it the dies directly used for striking the coins or medals are impressed. When the engraving is not very costly, a small number of impressions required, or a soft metal is to be stamped, as in livery buttons, for example, the work is stamped directly from the engraved die or matrix. See MINT.

Die-engraving is a very ancient art, and was perhaps first suggested by the closely allied art of engraving gems. Notwithstanding the great number of ancient Greek coins which have been preserved, it is stated by Mr R. S. Poole, of the British Museum, that only one of the many dies which were used for these has ever been found, or at least only one believed to be of undoubted authenticity. The Greek coins struck between the years 415 and 336 B.C. show that the art of engraving dies had then reached the highest point of excellence which it ever attained either in ancient or modern times. As works of art, the Italian medals of the 15th and 16th centuries come next in merit to Greek coins, but none of these of the 15th, and only the smaller sized ones of the 16th century time were struck from dies. All the others were cast either from wax models or from patterns made in other materials. The art of cutting dies.

in the comparatively deep intaglio required for medals, consequently dates from the beginning of the 16th century. Since then, or soon after it, Germany, France, Russia, and England, as well as Italy, have all had many more or less famous die-engravers.

The engraving of dies for medals is perhaps that branch of the art which gives the greatest scope for artistic skill, although the work on those required for coins is nearly identical in its character. Comparatively few dies of new design are, however, required for coins, while many hundreds of medal dies are annually made in England. The medals struck from these are used for such purposes as awards at exhibitions, colleges, and schools; for prizes at various games, and in commemoration of various events. Copper, bronze, and tin are the metals most commonly employed for medals, the copper being usually 'bronzed' on the surface. A copper medal with a head in moderately high relief requires half a dozen blows in the screw-press to bring up a sharp impression; but some in very bold relief require to be struck with as many as thirty blows. The medal requires to be frequently annealed during the process. Coins are finished at one blow, so that the devices upon them are only in slight relief. When a coin or a medal is being struck, a steel collar, accurately fitted to the die, is used to prevent the metal from spreading.

Dies have been extensively applied in Birmingham and other places to the manufacture of many kinds of objects in sheet-metal. These are of all sizes, from those required for parts of jewelry up to dies weighing more than a ton. Large and heavy dies are, however, cast, and only in some cases finished with the graver—those for such articles as curtain-pole and cornice ornaments being among the largest kinds worked up and finished with the die-cutter's tools. Dies have recently been used in America in the stamping or pressing of solid pieces of wood into lion's heads, rosettes, and other ornaments, in high relief, to imitate wood-carving. By the same process similar ornaments, in bas-relief, are made in pieces of wood formed of several layers of veneers.

Diffusion. The particles of all material bodies, except such as may be totally devoid of heat, are in rapid motion. In the case of solid bodies the excursions of any one particle are limited to a small space; but in fluids a particle may move more or less freely throughout the whole space occupied. This intermixture of molecules may occur also when different fluids are placed in contact with each other, but it may be prevented by the existence of tension at the common surface (see SURFACE-TENSION and CAPILLARITY). When it does occur, the fluids are said to *diffuse* into each other.

Diffusion of Liquids.—The diffusion of dissolved salts may obviously be considered under this heading. The phenomenon may be conveniently studied by introducing a strong solution of some highly-coloured salt, such as bichromate of potash, into the bottom of a tall glass cylinder nearly filled with water. The rate of diffusion varies with the nature of the liquids. Graham was the first to investigate the subject carefully. He filled a number of similar glass vessels with solutions of different salts. The mouths of these vessels were carefully ground so that they could be closed by means of glass plates. The different vessels were then placed in equal glass jars, and covered with water to a definite extent. Next the glass covers were cautiously withdrawn, and the diffusion was allowed to go on for a certain time. The rate at which each liquid diffused was thus obtained. Graham found that, for any one solution, the rate is proportional to the gradient of concentration—i.e. to the rate at which the quantity of salt dissolved per unit-volume varies per unit-length. Thus the law regulating diffusion of liquids is analogous to that which regulates the conduction of heat in a homogeneous solid. Hence the equations obtained by Fourier in his *Théorie de la Chaleur* apply to the problem under consideration.

Graham found also that rise of temperature greatly increases the effect. He divided substances into two classes, *Colloids* and *Crystalloids*, the members of the first class diffusing very much more slowly than those of the second. His investigations have been much extended by more recent observers employing various methods of observation.

If two miscible liquids be separated by a membrane of bladder or of parchment paper, &c., diffusion takes place through the septum at rates which are usually very different for different liquids. This phenomenon is known as *Osmose* (q.v.). It was first shown by Nollet that, if a vessel filled with alcohol be closed by a piece of bladder and placed in water, the diffusion of the water is so much more rapid than that of the alcohol that the bladder is burst because of the increase of the contents of the vessel which it closes. By this means the various constituents of a mixture of colloid and crystalloid substances may be separated to any desired extent. The rate at which liquids diffuse into each other through a septum depends greatly upon the molecular action between them and the septum.

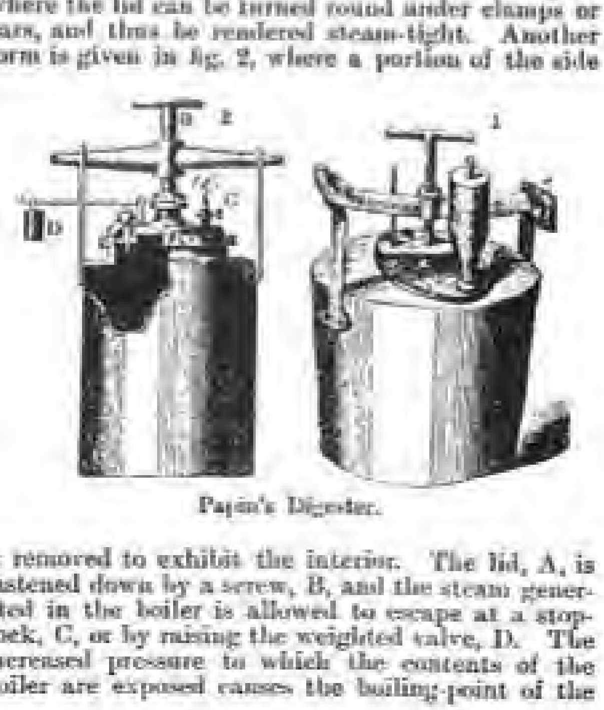
Diffusion of Gases.—If two flasks, each filled with a different gas at a given pressure and temperature, be placed in communication with each other, the gases will be found to interdiffuse. The rate of interdiffusion is shown by theory to be nearly in inverse proportion to the square root of the product of the densities of the two gases, and the experimental results are in accordance with the theory.

Effusion of Gases.—This is exhibited in the passage of a gas into vacuum under constant pressure through a small opening in a very thin plate otherwise impervious to it. The work done in the passage of a given volume of the gas is proportional to the pressure, and the equivalent kinetic energy is proportional to the product of the density and the square of the speed of effusion. Hence the speed for a given pressure varies inversely as the square root of the density. Graham showed that this result of theory is closely realised by experiment. He showed, further, that when a discrepancy exists, it is due to the finite thickness of the plate.

Transpiration of gases is the term to the passage of gases under pressure through a fine capillary tube. This subject was also investigated by Graham, who found that the rate of passage is not affected by the material of the tube. This seems to indicate that the tube becomes coated internally with a thin film of gas, so that the opposition to the flow of gas is due to Viscosity (q.v.).

The rates at which different gases pass through fine unglazed earthenware are inversely as the square roots of their densities. Hence we have a means of separating gases the densities of which are different (see ATMOLYSIS). If the septum be made of caoutchouc, which is not porous, the passage of gases still occurs. The gas seems to combine with the matter of the septum on the one side, to diffuse through it, and finally to be given off on the other side. The passage of some gases, such as carbonic oxide, through hot cast-iron is analogous.

Digester, PAPIN'S, is a strong boiler with a closely fitting cover, in which articles of food may be boiled at a higher temperature than 212° (100° C.). As its name implies, it was invented by Papin (q.v.), and a common form is the *Autoclave*, fig. 1, where the lid can be turned round under clamps or ears, and thus be rendered steam-tight. Another form is given in fig. 2, where a portion of the side



Papin's Digester.

is removed to exhibit the interior. The lid, A, is fastened down by a screw, B, and the steam generated in the boiler is allowed to escape at a stop-cock, C, or by raising the weighted valve, D. The increased pressure to which the contents of the boiler are exposed causes the boiling-point of the water to rise to 400° (204° C.), and occasionally higher. The digester is of great value as a means of preparing soups of various kinds, and especially in the extraction of gelatin from bones.

Digestion is the change which food undergoes in order to prepare it for the nutrition of the animal frame, and is carried on in the higher animals in the DIGESTIVE SYSTEM. In some of the lowest forms of animal life (amœbæ) particles of food may be drawn into the body (which possesses no special organs at any part of its surface), and may then be digested. In higher organisms, however, parts have become evolved, which serve more especially the function of digestion. Thus in the common sea anemone there is a simple pouch which leads inwards from the centre of the cluster of tentacles. Into this fish and other food are drawn and digested, while the undigested parts are afterwards voided through the same aperture by which they entered. In still higher organisms, man himself included, this simple pouch is changed into a complex and greatly elongated tube, which is provided with one aperture (the mouth) by which food enters, and another aperture (the anus) through which undigested matter leaves the body. The whole digestive system is lined with a soft membrane, which is richly supplied with blood-vessels. This membrane is called the mucous membrane, and from it is secreted by the glands which it contains a viscid substance called mucus. If the finger be thrust into the back of the mouth, and the mucous membrane gently scraped, the fluid which will adhere to the finger is seen to be viscid; it is secreted by the glands of the mouth. Not only mucus, but many other substances useful in digestion are formed by little glands in the mucous membrane, so that the whole digestive system is bathed during digestion with fluid having a digestive action on the food. In addition there are other glands, such as the salivary, the liver, and the pancreas, which we may look upon as glands of the mucous membrane which have enormously developed. To so great an extent have they increased in size that they have got far outside the digestive system, and have become situated in neighbouring parts of the body, only connected with the digestive system by their ducts or elongated mouths. Through these ducts their secretions, like that of the microscopic mucous gland, pour into the cavity of the digestive system. Outside the mucous coat we have the muscular coat, the function of which is to move the food onwards in its course, and to mix it with the digestive juices. In the mouth, throat, and the upper part of the gullet, the muscles which move the food onwards, as in swallowing, are, when examined by the microscope, seen to be transversely striped, and like other striped muscles their contraction is rapid. In other parts of the digestive system, however, the muscular coat consists of smooth muscle, and like all other

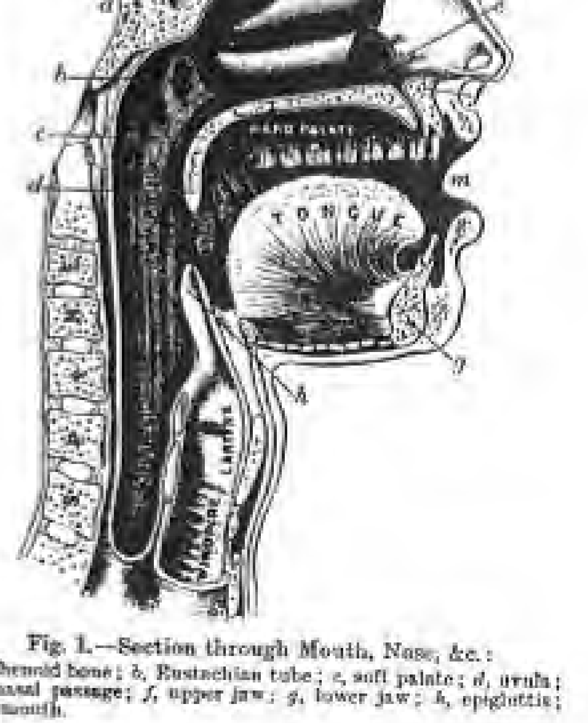


Fig. 1.—Section through Mouth, Nose, &c.:
a, sphenoid bone; *b*, Eustachian tube; *c*, soft palate; *d*, uvula; *e*, nasal passage; *f*, upper jaw; *g*, lower jaw; *h*, epiglottis; *m*, mouth.

smooth muscles this coat contracts slowly. On this account the food rapidly swallowed passes very slowly along the rest of the digestive system.

Having shown that the digestive system is a mucomuscular tube, we may now consider it more in detail. The mouth (fig 1, *m*) is lined with mucous membrane, and into it is poured the secretion of three pairs of salivary glands—the parotids, situated in front of the ear; the submaxillary, within the angle of the lower jaw; and the sublingual, under the tongue. The mouth in most animals is provided with hard tissues—teeth, beaks—for the subdivision of food before it is swallowed. Vegetable feeders, eating tough grains, roots, and fibres, have large molar or grinding teeth, while the carnivora have these same teeth modified so as to present a cutting edge, with which and their pointed canines meat is torn and cut into pieces, which are then swallowed (see TEETH). The mucous membrane of the mouth is covered externally by the muscles of the cheek and lips. Into its cavity the muscular tongue projects. On looking into the mouth with a looking-glass, one sees back into the throat. The entrance to the throat will be observed to be bounded at the sides by two muscular curtains passing downwards obliquely to the sides of the root of the tongue. These are termed the anterior pillars of the fauces, and behind them, one on each side, are masses of lymphoid tissue, subject to enlargement, called the tonsils. Above, another curtain hangs down. It is called the soft palate, and separates the mouth from the hinder part of the nasal cavity. Projecting from its centre is a little cone called the uvula (fig. 1). The cavity of the pharynx, or the interior of the throat, is another cavity lined by mucous membrane, with muscular walls. These muscles constrict it (constrictors). Below, the cavity passes into the gullet or œsophagus, and in front of this tube runs the windpipe which communicates with the pharynx through the larynx, or organ of voice. Food will pass through the pharynx into the gullet; and air, during respiration, passes through the pharynx on into the larynx and windpipe; a valve, called the epiglottis, partly closes the aperture of the larynx. The pharynx is common, therefore, both to the digestive system and the respiratory passages. Above, the pharynx communicates, as before described, with the mouth and also with the nose. One can demonstrate this latter fact by drawing smoke into the mouth, and expelling it by the nostrils. This communication is closed during the act of swallowing, and also during the singing of pure vowel-sounds, such as *a*, *aw*, and the closure is effected chiefly by the elevation of the soft palate, which acts as a valve. The pharynx communicates in addition with the middle ear by the Eustachian tubes, and this may be rendered evident if the mouth and nose be closed, and a violent expiratory effort made at the same time. As the pressure of air within the throat is increased, the Eustachian tubes which previously were collapsed now become distended, and a little wave of air at high pressure is forced into the middle ear, causing a buzzing sound. Occasionally the middle ear communicates with the external air through congenital or acquired apertures in the membrana tympani. In these cases smoke may be propelled from the throat out of one or both ears.

Fig. 2.—Human Alimentary Canal:

a, œsophagus; b, stomach; c, cardiac orifice; d, pylorus; e, small intestine; f, biliary duct; g, pancreatic duct; h, ascending colon; i, transverse colon; j, descending colon; k, rectum.

The gullet or œsophagus (figs. 1, 2, and 3) is a long tube passing from the pharynx to the stomach. Its mucous coat is beset with very large mucous glands, which secrete a quantity of very viscid mucus. Its muscular walls contain striped fibres in the upper, unstriped in the lower part. The stomach itself is a greatly dilated part of the digestive system. Its shape is indicated in the fig. It may be said to consist of two parts, even in the human subject; a more complex arrangement is found in many animals, such as the ruminants. The large dilated portion into which the gullet opens is termed *cardiac*, and the opening the cardiac or œsophageal opening. The narrow part opening into the duodenum is the pyloric part, and the opening the pyloric opening. The whole is lined with mucous membrane, which, in the empty stomach, is thrown into projecting folds or rugæ, but these folds are effaced when the organ is distended with food (fig. 3). In the

Fig. 3.—Section of the Stomach:
a, ducts of liver; b, pylorus; c, bile-duct; d, pancreatic duct; e, cardiac orifice.

membrane are innumerable glands, which secrete the digestive juices of the stomach (fig. 4). If the surface of the membrane be examined with a strong pocket lens, the apertures of these little glands may be seen. They run down from the surface into the deeper parts of the mucous membrane. They are lined by secreting cells. The greater number of glands situated in mucous membranes have the simple structure diagrammatically represented in fig. 4. Each gland has a mouth or short duct lined by cells. Below this the little tube is lined by cells which secrete the juice peculiar to the gland. This secreting part sometimes branches. Outside the gland blood-capillaries ramify, which supply the gland with nourishment, enabling it to manufacture the substances which it secretes. The gastric juice is acid, and the chief acid secreted is hydrochloric acid. This is formed at the cardiac, but not at the pyloric end. The substance called *pepsine*, which is necessary for digestion, is secreted by the whole of the glands. The cardiac glands therefore secrete both substances, and they possess two sorts of cells, those which form the hydrochloric acid being bigger and more granular than the other sort which secrete pepsine. The pyloric glands secreting pepsine have only one kind of cell similar to the pepsine-secreting cell of the cardiac end. Outside the vascular and glandular mucous coat, and united to it by a loose delicate layer—submucous coat—is the muscular coat. This is similar to that of the rest of the alimentary canal, except that there are in addition to the circular and longitudinal fibres, many oblique fibres. The circular fibres are very thick indeed at the pyloric aperture, forming a circular sphincter band, which contracts and keeps back the food in the stomach until gastric digestion is nearly completed.

The food, now called the *chyme*, passes into the small intestine, a tube some 20 feet long. This tube, besides the muscular and mucous coats, possesses in addition an external coat of loose fibrous

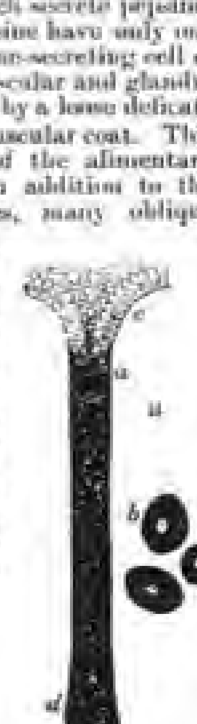


Fig. 4.

tissue, covered by a single layer of flat epithelial cells. This coat is prolonged into, and helps to form the mesentery, a membrane connecting the intestine with the abdominal walls, which are lined with a similar fibro-epithelial coat. This membrane is called the peritoneum, and is sometimes inflamed (peritonitis) as a result of cold, injuries, &c. The small intestine is somewhat arbitrarily divided into three portions—the upper (duodenum), the middle (jejunum), and the lower (ileum). In all parts the muscular coat is similar to that of the rest of the digestive system. The mucous coat contains glands very like the pyloric glands of the stomach, called Lieberkühn's follicles. These, however, rarely branch. They secrete the intestinal juice. In the duodenum, one finds in addition highly-branched glands called Brunner's. These extend right down into the submucous coat. Little is known concerning their function. In both the mucous and submucous coats, and generally involving both layers, are found masses of tissue—lymphoid—similar to that found in a lymphatic gland (fig. 6). These are termed solitary glands, but it must be understood that they do not secrete any juice concerned in digestion. Their function is probably connected with the blood and the blood-corpuscles. Collections of these solitary glands,

B, cardiac gland from the middle of the human stomach, magnified about 180 diameters: a, wall of the tube, lined with large oval nucleated cells; b, the same cells isolated; c, nucleated cells of columnar epithelium, occupying the upper parts of the tubes; d, blind extremity of the tube.

Fig. 5.—The under surface of the Stomach and Liver, which are raised to show the Duodenum and Pancreas:
st, stomach; p, its pyloric end; l, liver; g, gall-bladder; d, duodenum, extending from the pyloric end of the stomach to the front, where the superior mesenteric artery, sa, crosses the intestines; pa, pancreas; sp, spleen; a, abdominal aorta.

forming oblong patches about two inches long, are called Peyer's patches. These are affected in typhoid fever. In addition to the follicles of Lieberkühn and the glands of Brunner, there are two very important glandular structures, the liver and the pancreas, which pour their digestive juices into the small intestine (fig. 5). The bile, which is the secretion of the liver, is formed continually by that organ, but the amount thus formed is greatly influenced by the kind and quantity of food taken. It passes out of the liver by the two

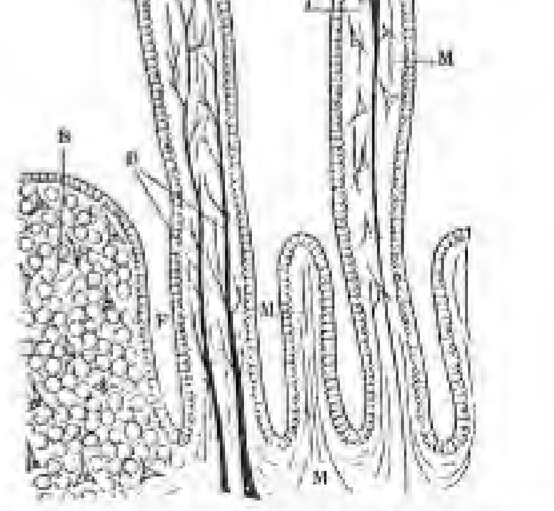


Fig. 6.—Section of Intestinal Mucous Membrane:
L, lacteal in centre of villus; E, epithelium covering villus; B, blood-vessels represented; F, follicle of Lieberkühn; S, part of a solitary gland; M, muscular fibres.

hepatic ducts, and much of it passes by the cystic duct into the gall-bladder, where it is stored up.

From this the bile passes into the common bile duct, which joins the duct of the pancreas, and the two open into the duodenum by a common aperture. The bile is to be looked upon not only as a digestive juice, but as a drain or channel of excretion, whereby effete and useless matters are removed from the body. The flow of bile is easily restrained, as by inflammation of the duct, or the presence of a tumour pressing on the duct, or a gall-stone. In this case, the bile already formed is reabsorbed with the blood, through the lymphatics, and we have jaundice due to absorption of the colouring matter of the bile. The secretion of bile goes on before birth; the meconium of infants consisting chiefly of biliary matter. The pancreas is very similar in structure to a salivary gland. It secretes the pancreatic juice which pours with the bile into the digestive system. The mucous membrane of the small intestine contains, in addition to the structures already mentioned, little projections called villi (fig. 6). These are not, to any great extent at least, secretive, but they are important absorbants. This property they share with the whole of the digestive system, through any part of which, and especially through the walls of the stomach and small intestine, digested matter passes into the numerous blood-capillaries which form everywhere a dense network. The villi are peculiar, however, for each one contains, in addition to blood-vessels, a small lymph-vessel or lacteal. Nearly all the fat absorbed by the digestive system is taken up by the little cells of the villi, and passes on into the lacteals, and thence to the blood (fig. 7). If some osmic acid, which blackens fat, be poured into the intestine of a milk-rabbit, killed during active digestion, and if the villi be examined with a microscope, they will be seen to have been blackened, especially at their tips, while the rest of the intestine will have preserved its ordinary colour. On further examination it will be seen that the fat has been taken up in microscopic globules by the cells covering the villi, and that they are passing, in a way which is as yet not definitely settled, into the central lacteal.

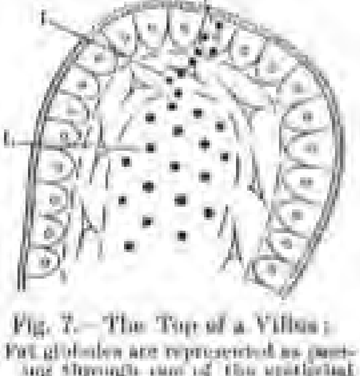


Fig. 7.—The Top of a Villus:
Fat globules are represented as passing through one of the epithelial cells, F, on through the tissue of the villus, L, into the central lacteal, L.

The small intestine is a tube of great importance, and in order to increase its total area, the mucous membrane is elevated, in the upper part, into transverse folds (the valvulæ conniventes, fig. 8).

The unabsorbed food, mixed with the various secretions we have mentioned, now passes into the large intestine, when both digestion and absorption go on, although to a less extent. The large intestine is only 5 feet in length, but its girth is much greater than that of the small intestine. It commences with the cæcum, a dilated part, into which passes a little blind canal (the vermiform appendix), a large and important structure in some animals. The food remnant (fæcal matter) is prevented, under ordinary circumstances, from passing back into the small intestine, by a double fold of mucous membrane (the ilio-cæcal valve, fig. 9). The large intestine ascends on the right side (ascending colon), crosses over to the left side (transverse colon), and descends again (descending colon), and makes a bend (sigmoid flexure), and finally terminates in a somewhat enlarged portion (rectum).

Fig. 8.—Small Intestine distended and hardened by alcohol, and laid open to show the valvulæ conniventes.

Fig. 9.—Cæcum inflated, dried, and opened to show the arrangement of the valve:
a, termination of the ileum; b, ascending colon; c, cæcum; d, a transverse construction projecting into the cæcum; ef, lips of the valve separating the small from the large intestine; g, the vermiform appendix of the cæcum

The anal aperture is closed by muscles, an internal sphincter of non-striped, and an external of striated fibre. The mucous membrane of the large intestine differs from that of the small intestine in containing no villi, or Brunner glands. Lieberkühn's and solitary glands are present, but the aggregation of the latter into Peyer's patches is nowhere to be found.

Movements of Food in the Alimentary Canal.—When food is taken into the mouth it is at once swallowed, unless it is in the solid form. In this case it is chewed or masticated; the use of which is to divide the solid fragments taken into a convenient size for swallowing, for which purpose it, in addition, is mixed with the viscid saliva and juices of the mouth. The chewed food, moreover, is more easily digested, inasmuch as the gastric and other juices can act more readily upon finely divided than upon larger masses of food. Many animals can hardly be said to masticate; such are the carnivora (dog, cat, &c.), and they are not provided with grinding teeth. In most animals living on vegetable food, which frequently consists of hard grains, roots, and fibres, large flat grinding molars are found. In these animals, not only is the food finely divided in the mouth, but the food, largely consisting of starch, is partially digested by the saliva. In mastication, the head is firmly fixed by the powerful muscles of the neck, while the lower jaw is moved upon the upper. The lower jaw is approximated to the upper by powerful muscles (the temporal, masseter, and internal pterygoids), which pass upwards, and are attached to the side of the head and face. Their contraction may be felt by placing the hand in front of the ear and voluntarily contracting the jaws. The lower jaw is depressed by muscles which pass down the front of the neck. Most of these spring from the hyoid bone, which may be felt deep in the tissues of the neck above the 'Adam's apple.' Rotating movements and those of protrusion and retraction of the jaw are produced chiefly by the action of the pterygoid muscles. It is obvious that during mastication the food would naturally tend to escape from between the grinding surfaces of the teeth, and would collect within the mouth and outside the gums. This is prevented, however, by the muscles placed in the substance of the cheeks (buccinators) and lips (orbicularis oris). These keep the cheek and lip walls closely opposed to the outside of the teeth. On this account food will only escape from between the grinders into the interior of the mouth, from which it is collected and pushed back between the teeth by the muscular tongue.

The very complex muscular movements just described result from very perfectly co-ordinated nervous impulses, which pass from the brain to the muscles, and cause and regulate their contractions. One can masticate 'at will'—that is to say, one can consciously cause the muscles to contract. In order that the mastication may be effective, however, it is necessary not only to know the sizes, but also to be aware of the ever-changing positions of the particles of food. This is effected by sensory nerves, which pass to the brain from the mucous membrane of the mouth. Although mastication is frequently voluntary, yet, like most other voluntary actions frequently performed, it can be performed reflexly. In this case the sensory impulses pass from the mucous membrane to the brain, and initiate appropriate motor impulses which pass to the muscles, without exciting attention and special volition in their passage.

As a result of mastication, the food is gathered in the form of a round moist bolus on the upper surface of the tongue (see fig. 1). It is now ready to be swallowed. In the first place, it is pushed backwards by the tongue, and seized by muscles, many of which are attached to the hyoid bone, which can be felt to move during their contraction. According to the most recent investigation, the bolus is propelled with great rapidity through the pharynx and gullet into the stomach. If the finger be placed upon the hyoid bone, or Adam's apple, and the ear placed against the upper third of the back of a patient, the movement of the hyoid bone indicating the commencement of swallowing is almost coincident with the passage of food down the gullet, which produces a very audible sound. Following the propulsion of the food downwards, there is a wave of contraction, which, commencing in the pharynx, travels downwards through the gullet. This, however, is comparatively slow. It is seen then that swallowing is not due to the falling of liquids down the throat. A horse drinks 'up hill,' and the jugglers, or indeed any one, can drink or swallow with the head vertically downwards.

When the food has reached the back of the mouth, the rest of the act of swallowing occurs irrespective of the action of the will. The nerves, which commence in the mucous membrane of the pharynx and gullet (sensory branches of vagus), carry impressions to the brain, which disengage of themselves the appropriate muscular movements without necessarily involving either the will or consciousness. Thus, in alcoholic stupor, or fainting from drowning, in both of which conditions consciousness is suspended, food and liquid placed at the back of the mouth are at once swallowed.

There is a possibility that during swallowing the food may go the wrong way—i.e. it may pass into the larynx and windpipe. It will be seen from the diagram that the food in its passage to the gullet must actually pass over the aperture of the larynx. It is prevented from passing into it by the elevation of the larynx (this can be felt by the hand placed on the throat), which pushes its aperture against and under the back of the tongue, which at the same time is pushed backwards. In addition, there is a valve called the epiglottis, which is pushed down over the larynx by the movement just described, and by muscular fibres, which act upon it for that especial purpose. If the epiglottis be destroyed, as by ulceration, gun-shot wounds, &c., it is necessary for the patient to have the food he takes carried over the aperture of the larynx into the gullet by a feeding-tube. It is obvious that one cannot speak with the larynx shut, and with the larynx open we cannot safely swallow. Food is prevented from passing into the nose by the elevation of the soft palate which meets the constricting pharynx, and shuts off the cavity of the nose like a valve (fig. 1).

The walls of the stomach and intestine are, like the gullet, provided with muscular fibre. An external layer passes in the length of the gut, and within this is a circular layer. These muscles, unlike the muscles of the limbs, contract slowly on stimulation, and they are outside the domain of voluntary action. During digestion they contract peristaltically, urging the food towards the rectum. The peristaltic waves may begin in any part of the gut and pass slowly downwards, followed at varying intervals by other waves. It is probable that what is called antiperistaltic waves may occasionally occur, tending to bring the food back towards the mouth, for bilious matter is frequently vomited, the bile having in all probability passed upwards into the stomach by antiperistalsis from the duodenum.

Eructations are frequently caused by antiperistalsis, and by a movement of this kind food is brought back into the mouth for further chewing in the ruminants (sheep, oxen, &c.). The peristalsis is particularly active during digestion, and is produced in great part by the food stimulating the mucous membrane. If a portion of the intestine or the stomach be removed from the body, peristalsis may continue or may be produced artificially, especially by irritating the mucous membrane. In the body the canal is under the influence of additional nerves (vagus), through which fibres the digestive processes are chiefly regulated among themselves.

The peristalsis in the stomach is combined by irregular churning movements.

The act of vomiting is a reflex nervous act. It can be excited by stimulating the branches of the vagus nerve, which are distributed to the stomach, as when indigestible and irritative food is taken; or emetics, such as mustard, hot water, or a hot saline solution, tartar emetic, ipecacuanha, sulphate of zinc, and alum are administered. By tickling the back of the throat with a feather, the glossopharyngeal nerve is stimulated, and vomiting may readily be produced. It is of frequent occurrence when painful irritation of the uterine nerves in pregnancy, of the nerves of the liver and kidneys during the passage of a hepatic or renal stone, or indeed when irritation of any sensory nerves takes place. Nerve-impulses may pass to the brain through any one of these channels (fig. 10), or may be excited in the brain itself by the sight or smell or even the thought of anything disgusting, and they produce, if the person be conscious, a feeling of nausea. In any case there is a discharge of nerve-impulses, which, as a result of this stimulation, passes to the glands of the mouth through the chorda tympani nerve, and produces a rapid flow of saliva. In addition, motor nerves carry impulses to the muscular walls of the abdomen, and to the walls of the stomach itself. As a result of the muscular contraction which follows, the contents of the stomach are propelled upwards into the mouth. Just before vomiting an inspiration generally occurs, and the aperture of the larynx (glottis) is closed.

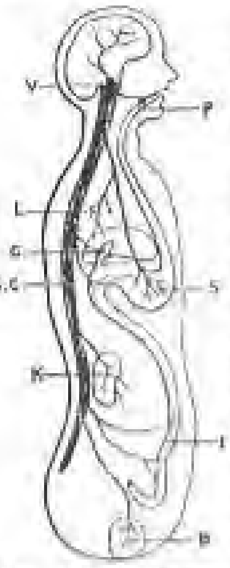


Fig. 10. — Sensory Nerves concerned in Vomiting:
Nerves come to vomiting centre V, through spinal cord SC, from pharynx P, lungs L, gall-bladder G, stomach S, kidney K, intestine I, and bladder B.

The diaphragm—the muscle which separates the thorax from the abdomen—then becomes pressed down upon the abdominal contents, and assists in the act of vomiting. Cases in which irritating or poisonous substances are swallowed are so frequent, that every one should be aware that a large quantity of hot liquid, especially if it contain much salt, or some mustard, forms a safe and speedy emetic.

Ice is a valuable sedative, and often prevents vomiting. The undigested food when it reaches the lower part of the intestine (rectum), excites sensory nerves which carry impulses to the brain and spinal cord. A feeling of distension results, and voluntary contraction of the abdominal muscles and of the diaphragm—an inspiration usually taking place—expels the undigested matter. This voluntary effort is aided by the contraction of the bowel itself, and by the relaxation of the band of muscular fibres (sphincters) which, during the intervals between evacuations, remain contracted.

In many animals, such as the sheep, ox, and camel, the stomach consists of several cavities communicating with one another. In the ox and sheep both the cardiac and the pyloric portions are each subdivided into two compartments. The cardiac part consists of a very dilated cavity, the paunch (rumen), into which the food is passed as soon as swallowed. In addition there is a smaller part, the reticulum (honeycomb), so called from the folds of lining mucous membrane which intersect, forming a reticulum. The pyloric half is divided into two parts. The psalterium (maniplies), so called from the lamellated appearance of its mucous membrane, communicates with the last division, the rennet stomach (abomasum, fig. 11).

Fluid passes either into the first, second, or third parts of the stomach, and thence on into the fourth. Solid matter, such as grass, roots, &c., passes either into the paunch or reticulum. This is mixed with the saliva swallowed with it, and in addition it is mixed with juices formed by the mucous membrane of these cavities. When the animal has finished feeding, it lies down and rumination commences. Due in part to the contraction of the abdominal muscles and diaphragm, the food is propelled in the form of rounded pellets from the paunch and reticulum up into the mouth. The pellets are there thoroughly masticated, and are returned in a pulpy condition to the stomach. Now, however, the food passes into the psalterium, and finally into the rennet stomach. It will be seen, therefore, that the consistency of the food determines into which part of the stomach it passes. The walls of the stomach near the gullet are thrown into two folds or lips which, when in contact, form a tube leading from the gullet into the psalterium. Along this tube the masticated and fluid food can pass. The mouthfuls of grass which are first swallowed pass

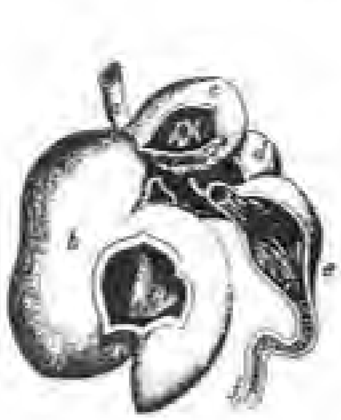


Fig 11.—Compound Stomach of Ox:
a, œsophagus; b, rumen, or paunch; c, reticulum, or second stomach; d, omasum, or third stomach; e, abomasum, or fourth stomach; f, the duodenum.

Fig. 12.—Alimentary Canal of Fowl:
a, œsophagus; b, crop; c, proventriculus, or secreting stomach; d, gizzard, or triturating stomach; e, intestinal canal; f, two long cæcal tubes indicating the theoretical commencement of large intestine.

between their lips, and find their way at once into the paunch or reticulum.

In the bird some interesting modifications in the structure of the alimentary canal are seen (fig. 12). The gullet at about the middle of its course is provided with a pouch or crop. Into this the food passes, and is bathed by a secretion formed by its glands. It is then propelled onwards into a dilated cavity, the proventriculus, and is acted on by digestive juices. Thence it passes into the gizzard. This cavity is provided with muscular walls of enormous thickness in the case of birds that are vegetable-feeders. It is lined by thick and corneous epithelium, and in its interior are generally found pieces of stone, chalk, &c. The gizzard is a powerful mill, which grinds the food into a soft pulp, upon which the digestive juices can readily act.

The Action of the Digestive Juices.—By digestion is meant that process by which food is rendered capable of passing through the walls of the digestive system into the blood-vessels and lymphatics, in such a form that it may be of use to the economy. The most essential change which food undergoes is one of solution. Albumen, starch, fat, and other food-stuffs are quite insoluble in the circulating fluids of the body, and were they injected into the blood they would simply block up the smaller blood-vessels. During digestion these pass either into nearly allied chemical substances which are readily dissolved in water, or in the case of fat partly into a soluble soap, and partly into a state of microscopically minute subdivision. It is not sufficient, however, merely to have a soluble food-stuff in order that it may be absorbed and used by the body. Cane (table) sugar is soluble in water, but it is of no use as cane-sugar to the body. If injected into the blood-vessels, it is at once secreted by the kidneys. During digestion it is converted into another sugarless soluble, but in a form which can be used by the economy.

It must clearly be understood that food introduced into the stomach is not received into the system. It is still 'outside the body.' It is only when it has become absorbed, and has passed in a suitable form, carried by the blood, to the tissues of the brain, muscles, &c., that it is made use of in so-called vital manifestations. The relief and stay that a meal gives is chiefly due to nervous action, the result of gastric distension. Clay and other non-nutritive matter may be swallowed, and will temporarily produce the same effect.

The digestion of food is brought about by the action of juices, the saliva, the gastric, pancreatic, intestinal, &c. These are mixed with the finely divided food by the movements of the alimentary canal. The digestive juices are in all cases secreted by the microscopic cells which line the various glands opening into the digestive system. The digestive juice, whatever be its source, contains either an acid substance or an alkaline one, and in addition a substance termed an unorganised ferment. These ferments differ in many particulars from the organised ferments (bacteria, micrococci), found in putrefaction, diseases such as anthrax, scarlet fever, cholera, &c. The latter are whole living cells, having definite parts or organs. They live and multiply, consume, and excrete in the fluid they inhabit. The digestive ferments are not whole cells, they are the *products of cells.* They are not the broken-down useless substances, such as carbonic acid, water, &c., which all cells give out, and which an animal, like man (an aggregation of cells), excretes. They consist of very complex active matter, of which we know almost nothing, and which we class with some other substances of which we know little more, under the head 'albuminoids.' These ferments in fact possess many of the qualities of cells themselves. They are killed by the temperature of boiling water, like all other living things. They have a certain range of temperature, within which alone they evince activity, and within the limits of that range they are more active the higher the temperature. Then again they require the presence of water, in which fluid they are soluble. In their action they seem to be hydrolytic, that is, they produce important changes in the substances they attack by, amongst other things, adding the elements of water. These digestive ferments, together with the other constituents of the digestive juices, are secreted by the cells of the digestive glands. If we study these glands and their cells with the microscope, they all present several points of similarity. Each gland has a duct, which, as in the case say of the salivary glands, divides into several branches. The duct, or its branches in the latter case, terminate in the secreting tubules of the gland. These are little tubes, which are lined by the secreting cells, leaving only a small cavity in the centre of each tubule for the escape of the secretion into the duct. Outside the tubule there is a dense network of fine blood-capillaries, from which the liquor of the blood escapes, bathing the gland and the cells within it. These imbibe the liquor, and they have almost certainly the power of selecting such constituents of it as they require. The substances derived from the blood are used by the cells, which manufacture the juice which they excrete. The constituents of the excretion are not found, it will be observed, in the blood; they result from chemical processes which go on within the cells, which use blood as a raw material. The cells are very small, being about $\frac{1}{1500}$th to $\frac{1}{1000}$th of an inch across. They have each a very thin envelope, within which the finely granular contents of the cell are seen. In the centre is a kernel or nucleus. During digestion the cell enlarges, and granules appear in it. These are the manufactured products; they are discharged into the duct of the gland.

We have now to consider how it is that the glands are regulated in their secreting powers, how it is that at certain times, and in sufficient quantity, the secreting juice is poured into the digestive system. This is brought about by the action of the nervous system. Although in some cases—e.g. the stomach, local nerve-cells placed in the walls of the digestive system itself, seem to regulate in part the secretion, yet in all cases nerve-cells placed in the brain are chiefly concerned. It was thought at one time that the brain acted by causing the blood-vessels of the gland to enlarge, and in consequence the food-supply and secretion of the gland to become greater. That this is not the whole truth, is shown by the administration of belladonna. If a rather large dose of this drug be taken, the mouth becomes very dry and unpleasant, and it is difficult to speak and to swallow. In other words, the cells of the salivary glands are paralysed, and the customary flow of saliva is for the time being at an end. It is found, however, that during this condition the blood-vessels are by no means contracted. This experiment, together with others, suggests that although during the secretion of a digestive juice the blood-vessels dilate, the activity of the secreting cells is not always associated with the condition of the blood-vessels. The latter are undoubtedly under the influence of nerves (vaso-motor) which regulate their condition, and it is probable that the secreting cells are themselves under the influence of other nerves, which are special secreting nerves. We have already seen that in the case of the movements of the digestive system, the motor-impulses which started from the central nervous system were called into action by sensory impulses starting from the mucous membrane of the digestive system. So in like manner the nervous impulses which pass to the blood-vessels and the glands are caused, in the first instance, by sensory impulses from the mucous membrane. If food be taken into the mouth, especially if it be 'tasty,' a secretion of saliva rapidly follows, and even the tickling of the mouth by a feather, or the stimulation of the mucous membrane with electricity, will produce the same result. In this case sensory impulses pass to the brain through such nerves as the lingual and glossopharyngeal, and reflexly excite the glands through the medium of the brain, the outgoing impulses passing through nerves such as the chorda tympani (fig. 13). See BRAIN. In the case of salivary secretion, the smell or sight of food may excite a secretion. In this case the sensory impulses pass from the nose or eye along the nerves of these organs to the brain. When the thought of food produces a flow, this is due to the recalling of previous sight and smell impressions in the brain.

When food is passed into the stomach, secretion occurs. This too may result from mechanical irritation, as when through an opening (fistula) the mucous membrane is brushed with a feather. In all cases the stomach, pale before, becomes suffused with blood, and the gastric juice is poured out. The flow of the intestinal juice, the pancreatic juice, and bile, all follow the stimulation of the mucous membrane, and in all cases the blood-vessels enlarge so as to give the cells a good supply of food, although, as we have seen, they themselves actually pass into a condition of activity, as a result of the influence of special secreting nerves.

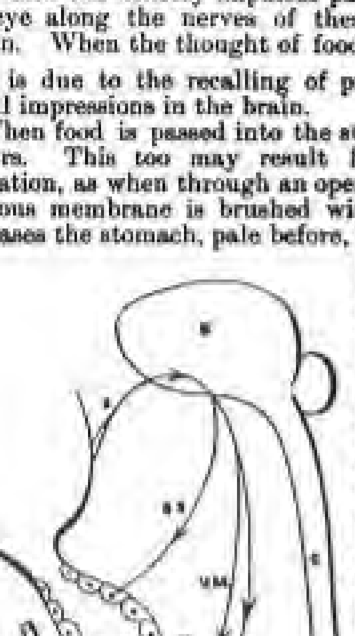


Fig. 13.—Nervous Mechanism of Secretion:

B, brain; C, spinal cord; S, nerve passing from mucous membrane of mouth to brain; SS, nerve passing to cell in salivary gland; VM, nerve passing to blood-vessels of gland.

We have now to consider the digestion of food-stuffs, and the parts that the various glands play in this important process. For our present purpose it is sufficient to speak of foods as belonging to four classes: (1) Proteids—albumens, globulins, &c.—e.g. the white of egg, the chief constituent of meat, the gluten of bread. (2) Carbohydrates—starches, sugars, gums—e.g. potato-starch, cane or grape sugar. (3) Fats and oils—e.g. suet, marrow, olive-oil. (4) Minerals—e.g. water, table-salt, iron, phosphates. See also DIET, FOOD.

Some few substances are absorbed without being digested at all; they do not need to be. Such are water and the minerals, although even many of these undergo some change or other. Grape-sugar is absorbed, and probably proteids too are often absorbed to some extent at least. Fat is profoundly modified during digestion, although not as the result of any digesting ferment. It may be said, however, that the great mass of food-stuff which is classed under the heads of proteids and carbohydrates is all digested by the action of ferment-like bodies. The saliva, of which about 30 ounces are secreted during the 24 hours, contains a ferment termed ptyalin, which is capable of turning starch into a soluble sugar called grape-sugar, or according to other observers, into another soluble sugar termed maltose. This can easily be demonstrated in the following manner: Take a tiny pinch of ordinary starch powder, and shake it up with a tablespoonful of water. It will not dissolve. Then boil it, when the starch will swell up, forming a thin starch paste. Dilute a few drops of tincture of iodine with several volumes of water, and add a drop of this to a small quantity of the starch paste. It will become of a rich blue colour. This is the test for starch. Now add to some of the original starch paste about one quarter of its volume of saliva from the mouth, and keep the mixture by the fire at a temperature pleasant to the hand. In a minute or so take out some of the starch in order to test it again. The iodine no longer gives a blue colour, but produces a beautiful mahogany brown. This shows that the starch has disappeared, the brown colour being the reaction given by erythro-dextrine into which the starch has been converted. After a little time another portion tested in a similar way gives no reaction whatever, the erythro-dextrine having in its turn disappeared. The starch is now converted into sugar, mixed with a little unconverted dextrine. This being an achroo-dextrine, uncoloured like the erythro-dextrine by tincture of iodine,

$$\underset{\text{Starch.}}{C_6H_{10}O_5} + \underset{\text{Water.}}{H_2O} = \underset{\text{Grape-sugar.}}{C_6H_{12}O_6}.$$

The ptyalin may be extracted from the saliva or from the salivary glands themselves. It does not appear to be much exhausted during its activity, and has the general characters already discussed of unorganised ferments. The saliva is alkaline, and the starchy food is no doubt partly converted into sugar during its sojourn in the mouth and gullet by its action. When the food has reached the stomach and the acid gastric juice has mixed with it, the saliva is unable to act, and is probably killed. Any undigested starch is subsequently converted into sugar when the food reaches the small intestine by the pancreatic juice.

When the food reaches the stomach it causes a reflex secretion of gastric juice. This is but slowly produced when insipid heavy food, such as coagulated white of egg, boiled meat, sago, &c., is eaten, but flows readily when soups, broths, and fluids containing salts and extractions in abundance are taken. Thus we have a scientific reason for commencing a dinner with soup, preserving the *pièce de résistance* until the stomach has secreted gastric juice for its digestion. The gastric juice, several pounds of which are secreted daily, is acid in reaction containing free hydrochloric acid. In addition lactic and butyric acids are formed during the progress of digestion. The ferment peculiar to the stomach is termed pepsine, and it requires, unlike the ptyalin of the saliva, an acid medium for its action. Pepsine and hydrochloric acid convert proteids into substances termed peptones. The latter bodies are soluble in water, and are not coagulated by boiling like many of the proteids. In addition they pass readily through an animal membrane, and are therefore easily absorbed. The proteid does not pass directly into the peptone, but like the starch is changed into at least one intermediate body. In the first case the proteid becomes converted by the hydrochloric acid into what is called syntonin, or acid protein, and it is this syntonin which alone the pepsine has power to change into peptone. The syntonin becomes a propeptone which is intermediate in its properties between a proteid and peptone itself. It is very probable that the whole change from proteid to peptone consists in some simple change in the molecular character of the proteid, together with the addition of water. A peptone may be termed therefore a hydrated proteid, and the pepsine a hydrolytic ferment. Within the stomach, and capable of being readily extracted from the stomach of a calf, is a ferment called the milk coagulating ferment (rennet). This causes milk to coagulate, and form a clot or curd. It subsequently contracts and squeezes out some fluid termed the whey. It is difficult to assign any use to this ferment, for the acid of the gastric juice would cause of itself the milk to curdle. Still more difficult is it to explain the existence of a similar ferment in the pancreatic juice, for we cannot suppose that any milk can even pass through the stomach to be subjected to its action. The milk indeed often forms dense clots which cannot afterwards be digested, and which cause considerable gastric irritation. Milk when drunk is frequently found to disagree with some stomachs; but even in such cases it may often be 'sipped' with impunity. In this case the formation of large clots is prevented. Lime-water causes the milk to coagulate in small soft clots.

The products of digestion, peptone and sugar, together with water and many soluble salts, are absorbed into the blood-vessels which ramify in the gastric mucous membrane. When gastric digestion is over, the undigested food (chyme) passes through the relaxed pyloric sphincter into the small intestine. The chyme consists of some proteid and starchy matter, together with fat and oil and indigestible substances such as vegetable fibre, pure wax, cartilage, &c. mixed with gastric juice. Intestinal digestion is an alkaline one, and all the digestive juices of this part of the digestive system are alkaline in their reaction. They soon counteract the acidity of the chyme, which now becomes alkaline. The proteids which remained undigested by the stomach are now acted upon by a ferment called trypsin found in the juice of the pancreas. This converts the proteids into peptones through an intermediate propeptone. The pancreatic juice contains other ferments which operate during digestion, notably a hydrolytic ferment, similar in its action to ptyalin, whereby the remaining starch is converted into sugar. The juice itself is thick and viscous. It is strongly alkaline and secreted in rather small quantity. It is said to possess a ferment capable of splitting oil and fat into glycerine and fatty acid, which it does by adding water to the fat, which is then decomposed. The fatty acid unites with the free alkali present, and a soap is formed which is subsequently absorbed. The alkaline contents of the alimentary canal also emulsify fat—i.e. they cause it to become very freely divided, forming a milky fluid. The minute microscopic globules which result pass readily through the walls of the alimentary canal into the lymphatics (lacteals). The emulsification of an oil can readily be shown by adding about half its volume of carbonate of soda (3 per cent.) solution to cod-liver oil. The latter becomes at once very similar to milk in its appearance.

The intestinal juice, the secretion of Lieberkühn's follicles, is strongly alkaline. It assists in the digestion of starch and of proteid matter. In addition an important ferment called 'invertin,' is found. This has the power of changing cane into grape-sugar and an allied substance, lævulose. Both these bodies have the same formula, but differ from one another in their action on polarised light,

$$\underset{\text{Cane-sugar.}}{C_{12}H_{22}O_{11}} + \underset{\text{Water.}}{H_2O} = \underset{\text{Grape-sugar.}}{C_6H_{12}O_6} + \underset{\text{Lævulose.}}{C_6H_{12}O_6}.$$

The importance of this ferment will be appreciated when we consider how large a quantity of food is taken in the form of cane-sugar, and that cane-sugar introduced into the blood is not of any use to the body, and is eliminated at once by the kidneys. The bile may be looked upon both as an excretion from the body and as a digestive juice. The colouring of the fæces and urine is due in part to a pigment hydrobilirubin (urobilin), which is an altered bile pigment. If bile is excreted rapidly, the fæces are dark in colour, and they may be white owing to deficient excretions. Many substances such as mucin, cholesterin, &c. found in the bile are excreted to form part of the fæces. On the other hand many bile constituents, such as the bile salts, are reabsorbed and used again in the economy. Bile has an important action in digestion, as may be shown by making biliary fistula in dogs, whereby the bile leaves the body at once through an aperture in the abdomen. In this case the animal loses flesh; the fat which it takes with its food passes unabsorbed through its digestive system, and its excretions are offensive. The bile seems then to assist in fat absorption, and to have some antiseptic action whereby putrefaction is prevented or lessened within the digestive system. Bile assists in the absorption of fat not only by assisting in its emulsification, but also by helping in some way or other the epithelial cells, covering the villi to take up the minute fatty particles. In addition it is supposed to stimulate minute muscular fibres within the villi, which by their contraction pump the absorbed fat on into the larger lymphatics.

Within the small intestines most of the food undigested by the stomach is rendered fit for absorption. This takes place through the tissue of the mucous membrane; much of the sugar and peptones find their way into capillary blood-vessels. Absorbed products, and notably fat globules, pass into the lacteals, and thence into the blood, circulating through the veins at the root of the neck. The contents of the lacteals during absorption are called *chyle*. The contents of the small intestine pass into the large intestine, where digestion occurs to a very slight extent. Absorption is, however, more rapid, and the contents become far more solid as they pass towards the rectum, due to the deprivation of water and soluble substances. The absorptive power of the large intestine is important to remember; for injections per rectum of liquid food, especially if it has already been artificially digested, may frequently sustain life for long periods.

Artificial Digestion.—The digestive juices are occasionally defective in amount or in quality, and in this case they may be supplied artificially. All the digestive ferments may be separated by very simple processes from the glands which secrete them, and many may readily be obtained in the market. Pepsine and hydrochloric acid, taken with or before a meal, are often of great service, the most reliable preparations of pepsine being the ordinary pepsina porci. Food may be digested *outside the body* before its administration. Beef-tea and milk-gruel may be prepared in the following way: To bring the food to the proper temperature, boil half of it, mix it with the other half, and keep warm near the fire. To this add a preparation of the pancreatic ferments in the proportion given in the directions which invariably accompany the bottle containing the substance. The food should now be kept warm for an hour or so, and then boiled in order to prevent any further action of the ferment. It may be taken by the mouth or administered as an enema. Preparations of the pancreas are alone to be used in peptonising food outside the body, as pepsine preparations produce a bitter and unpleasant taste. Pancreatic preparations on the other hand are useless when taken with the food, as they are destroyed within the stomach.

Digita'lis, a genus of Scrophulariaceæ, natives chiefly of the south of Europe and temperate parts of Asia. One only, the Common Foxglove (q.v.), (*D. purpurea*), is a native of Britain. Other species have been introduced, notably *D. lutea* and *grandiflora*, with yellow flowers. The botanical name Digitalis (late Lat. *digitale*, 'the finger of a glove') refers, like the popular English name, to the form of the flowers.

The leaves of the *Digitalis purpurea*, collected before the expansion of the flowers and dried, are largely used in medicine, either in the form of powder, or as tincture or infusion. Digitalin granules, containing minute quantities of a mixture of the active principles, are also employed. The leaves owe their activity to the presence of certain bodies, which have been named digitalin, digitalein, digitoxin, and digitonin, the three first mentioned having the characteristic digitalis action, while the fourth is entirely different, and closely resembles saponin in its effects. The leaves and their preparations have a bitter taste. When given in large doses by the mouth, they produce violent vomiting and purging; this may prevent their absorption into the blood, but if absorbed, they may cause death by paralysing the heart's action. When the leaves are administered in medicinal doses, a peculiar action is exerted on the muscular substance of the heart and blood-vessels, causing the former to beat more slowly, regularly, and powerfully, and contracting the latter. By this combined action the blood-pressure is raised, and if dropsy be present, a diuretic action is exerted. Digitalis is also used in many organic forms of heart-disease, in nervous and functional irregularity of the heart's action, in cardiac weakness from long-continued disease, in œdema of the lungs, internal hemorrhages, and other conditions. When taken for a long time it may cause nausea and other digestive disturbances, and in a very few cases sudden and serious symptoms of poisoning come on. This constitutes the so-called *cumulative* action of digitalis. In therapeutic doses digitalis should slow the pulse; if too large doses be given, the pulse becomes rapid and irregular.

Dippel's Animal Oil, a panacea invented by Johann Konrad Dippel (1673–1734), a German chemist and alchemist. It was obtained in the manufacture of ammoniacal products by the distillation of bones. A mixture of oils passes over, and these, after being repeatedly distilled, eventually yield an aromatic liquid, free from fetid odour. This obtained a great reputation as an antispasmodic, and being present in the old spirit of hartshorn, gave it properties somewhat different from those of the modern sal volatile. Owing to the careless way in which it was usually manufactured, and the consequent disgusting odour and taste which it possessed, it has been quite discarded and is no longer used in medicine.

Distemper is a typhoid inflammation affecting the mucous membranes of young dogs, and resembling in many respects the strangles of young horses, and the scarlatina and other such complaints of children. Like these, it is generally contagious, occurs only once in a lifetime, runs a definite course, is accompanied by low fever and debility, and is most successfully treated by good nursing and attention to diet and regimen. It is divided into five different forms—catarrhal, pneumonic, intestinal, hepatic (known as yellows), and nervous. The catarrhal always accompanies and frequently precedes the other forms. The eyes are red or yellow, weak, and watery; the nose dry and hot; draughts of air or movements of the animal readily excite sneezing or cough; there is dullness, fever, and loss of appetite. The thickened slimy mucus which the inflamed membrane after some days secretes, accumulates about the eyes and nostrils, and lodging in the bronchial tubes, prevents the free access of air and the proper purification of the blood. Hence ensue distressed breathing, increasing weakness, and symptoms of nervous disturbance, such as staggering gait, chorea, and fits. All dogs are liable to distemper, but the delicate and highly bred varieties suffer most severely, and amongst them the mortality is very great. Bleeding, physicking, and all irritating and reducing remedies, must be carefully avoided, and a good dry bed in a comfortable airy place provided. The stomach, which is generally overloaded, should be relieved of its contents by an emetic, which, for an ordinary sized English terrier, may consist of two grains each of tartar emetic and ipecacuanha, with eight or ten grains of common salt, given in a wine-glassful of tepid water. If no effect is produced, the dose must be repeated in twenty minutes. Constipation, if present, should be corrected by half an ounce each of castor and olive oil, to which, in large dogs, a few grains of gray powder is a useful addition. The febrile symptoms, if acute, may be alleviated by giving four times daily, in cold water, five drops of laudanum, and five grains each of nitre and hyposulphite of soda. Distressed breathing will be relieved by applying to the chest and sides, for an hour or two continuously, a thick flannel cloth, wrung at short intervals out of hot water. The throat may also be rubbed with hartshorn and oil, and the nostrils sponged and steamed occasionally. Give frequently, and in small quantities at a time, milk and bread, or any other such simple and digestible food; and when recovery is tardy, and weakness ensues, endeavour by nursing, tonics, and stimulants, to support the strength. See *Management and Diseases of the Dog*, by J. Woodroffe Hill (new ed. Lond. 1881).

The term distemper is sometimes applied to Influenza in horses, and epizootic Pleuro-pneumonia (q.v.) in cattle.

Distillation is the name given to the process of applying heat to a liquid, or, it may be, a solid, in order that certain constituents may pass away in vapour, and, by suitable arrangements, be obtained in the form of a liquid. When the vapour does not condense as a liquid, but only as a fine dust or flour, the process is called *Sublimation* (q.v.). The natural evaporation of water, by the heat of the sun, or warm air currents, the ascent of the vapour into the colder regions of the atmosphere, and the condensation there into clouds and mists, with the subsequent rain-shower, form together the grandest example of distillation. The apparatus for artificial distillation essentially consists of three parts, the Still (or RETORT, q.v.), Condenser, and Receiver. The *still* is made of glass, copper, iron, or earthenware, according to the nature of the substances to be placed in it. In experimental chemical work, glass is almost the only material admissible, while in the preparation of alcohol from grain, copper-stills are commonly employed. The *condenser* is made in an infinity of forms, the object being to condense the vapours disengaged from the still as rapidly and effectually as possible. For this purpose it is important that the condenser shall expose a large surface to the cooling medium, water or air. Owing to its rapidity in conducting heat, and the thinness of pipes made of copper, this metal is generally employed in the construction of condensers. Whatever the form, the principle is the same—viz. that the hot vapours pass through a tube or vessel surrounded with cold water, which running in a constant stream, passes away more or less warm after it has done its work. The *receiver* merely consists of a suitable vessel in which to receive the *distillate*. As the forms of apparatus are capable of infinite variety, so the conditions of distillation are innumerable; the best defined types going under the names of Fractional Distillation, Destructive Distillation, and Distillation in Vacuo.

In *Fractional Distillation* a mixture of liquids having different boiling-points is put in the still and heat is applied. If the vapours were allowed to pass over together and the distillate to be received in a single receiver, it is evident that nothing would be gained; for the different liquids would re-mingle in the receiver. If, however, the temperature be raised very slowly, and especially if the vapour requires to rise through a high *head*, or tube, before passing into the condenser, it will be found that the more volatile liquids pass over first in a state of comparative purity, and while the others follow as the heat is increased. If the receiver be frequently changed, a series of *fractions*, or portions of liquid, are obtained, corresponding to the different substances present in the still. For example, if a mixture of glycerine, water, alcohol, chloroform, and ether were distilled, the ether would distil first, then the chloroform, next the alcohol, and lastly, the water, while nearly all the glycerine would be left behind. This then is fractional distillation.

Destructive Distillation, or Dry Distillation as it is sometimes called, is best exemplified when coal is heated in an iron still or *retort*, as in the manufacture of gas. Now, in coal there are only traces of moisture capable of distillation, but when strongly heated, the coal is destroyed, or *decomposed*, and a large number of substances distil over, some of which, like lighting gas, are permanently in the gaseous state, others like Creasote (q.v.) are liquid, while others, such as naphthaline, are solid bodies at the ordinary temperature. Here no distillation takes place until the substance heated is destroyed, hence the term destructive distillation. Further examples are the distillation of wood in close vessels, at a red heat, when charcoal is left in the vessel, and wood-vinegar, wood-spirit, tar, &c. pass over in vapour, and are condensed; and the heating of bones in similar retorts, when animal charcoal is left in the retort, and Dippel's animal oil distils over. See CHARCOAL, COAL-TAR, and DIPPEL'S ANIMAL OIL.

Distillation in Vacuo.—When water is heated in a kettle it eventually boils, and if a thermometer be plunged into it, the mercury is seen to remain stationary at a temperature of about 212° (100° C.). It will be noticed, however, that when the barometer is low, the temperature of the boiling water is somewhat below 212° (100° C.), and that when the barometer is very high, the temperature is also high. On the summit of Mont Blanc, it is found that water boils at about 180° (82° C.); while in a vessel from which the air has been removed by an air-pump, it continues to boil even when the temperature falls down to the freezing-point (see BOILING.) There are many substances which are injured by heat, such as extract of malt and sugar, and when solutions of these bodies require to be evaporated on a large scale, they are always distilled *in vacuo*, so that the water may be removed without unduly heating the vessel.

There is another very interesting method of distillation whereby liquids which, alone, cannot be distilled without decomposition, are made to distil in presence of the vapour of some other liquid. Thus, glycerine is not, practically speaking, capable of being distilled, but when heated with high-pressure steam, it readily distils over, and can thus be purified. The great object of distillation is purification, and in the manufacture of the fragrant volatile oils of lemon, lavender, &c., it is necessary to distil them along with water so as to avoid overheating of the oils, and consequent injury. Not only is the flavour improved by this treatment, but they distil at a lower temperature along with water than when alone. The term distillation in excise language refers to the distillation of alcohol alone. For information on this subject, see FERMENTATION, ALCOHOL, BRANDY, GIN, SPIRITS, and especially WHISKY; under which latter head the subject of the duties payable and of illicit distillation are also treated.

Distilled Water is the condensed product obtained by the distillation of water. All natural waters, even rain-water, contain certain saline matters (common salt, &c.) in a state of solution, from which they can only be completely freed by the process of distillation. The characteristics of distilled water are, that it possesses a mawkish, insipid taste, without odour or colour, and when evaporated to dryness in a vessel, it ought to leave no residue. Unless very specially prepared, it is sure to contain traces of free ammonia, and, when this is the case, it is liable to form a green vegetable growth in any bottle containing it. The other properties of distilled water will be noticed under WATER.

Distilled Waters is the name for what is obtained by distilling water along with the parts of plants containing essential oils. Rose-water and lavender-water are familiar examples.

Diuretics, medicines having the property of increasing the secretion or excretion of urine, and on this account much employed in dropsies, as well as in a variety of other diseases. The principal diuretics are the salts of potash, especially the nitrate, acetate, and bitartrate (cream of tartar); squill, in powder, vinegar, or syrup; digitalis or foxglove, in powder or infusion; the decoction or infusion of broom-tops (*scoparium*); nitrous ether (in sweet spirit of nitre); caffeine, the active principle of coffee; the alcohols and ethers, with most of the volatile oils, especially that of juniper, as in gin; the berries of the common elder; the tincture of cantharides or Spanish flies; turpentine, &c. The last named (from the alcohols onwards in the above enumeration) are more or less irritating in their effects on the urinary organs, and should not be used without due consideration as to the requirements of the particular case. Cream of tartar and the broom-decoction form one of the safest and best diuretic mixtures which can be employed in domestic use; or cream-of-tartar may be given alone, either dissolved in hot water and allowed to cool, or in substance along with syrup.

Ductility is that property of solids in virtue of which they can be drawn out so as to increase their length at the expense of their cross dimensions. Thus silver is a very ductile metal, while platinum is not so ductile. But although platinum cannot be drawn out to any very great extent by the ordinary process of wire-drawing, it may be drawn out by Wollaston's process. Wollaston fitted a platinum wire into the interior of a hollow rod of silver, and then drew out the compound rod to an extent limited only by the ductility of silver. He then dissolved off the silver, and so obtained an excessively fine platinum wire, the diameter of which was, according to Leslie, [illegible] inch. Leslie also says that, by drawing out a thickly-gilt silver rod, a film of gold only [illegible] inch in diameter could be obtained. See MALLEABILITY, WIRE.

Dulse (*Rhodymenia palmata*), a seaweed, one of the Florideæ (see SEAWEEDS), growing on rocks in the sea, and used as food by the poor on the coasts of Scotland, Ireland, and other northern countries. It is eaten raw or roasted, and with vinegar. It is an important plant to the Icelanders, and after being washed and dried, is stored in casks, to be eaten with fish or boiled with milk. In Kamchatka, a fermented liquor is made from it. Sheep are fond of it.—One or two other edible Florideæ bear the same name on different parts of the coast, and the pungent *Laurencia pinnatifida* is known as pepper dulse.

Dyeing is the art of imparting colours to textile and other materials, such as cotton, silk, wool, and leather. It has been practised among eastern nations from time immemorial; and in the Old Testament, we read of the purple-dyed vestments of the high-priests, of linen cloths dyed blue, purple, and scarlet, and of rams' skins dyed red. The famous Tyrian purple, obtained from one or two species of shell-fish, is believed to have been discovered by an inhabitant of Tyre fifteen hundred years B.C.; afterwards this purple became the badge of royalty, and cloth dyed with it commanded a princely price. Purple of various shades was dyed not only at Tyre, but at Tarsus, Alexandria, and other places on the shores of the Mediterranean, though other colours were of course employed. The Egyptians, Greeks, and Romans practised the art of dyeing. There is an ancient Roman dyer's workshop with its apparatus to be seen among the ruins of Pompeii. Gradually the art became more and more widespread as civilisation advanced. In earlier times, dyeing was much more extensively followed as a domestic art than it is at present, but in some outlying parts of Europe and even in the Highlands of Scotland, the colours imparted to home-made fabrics are still to some extent obtained from native vegetable dyes. Many of the ordinary dye-stuffs and dyeing agents have been used in England for more than four centuries, and to these America added cochineal, as well as some important dye-woods and barks. Dyeing with colours obtained from natural products had reached a high state of perfection when Perkin, in 1856, introduced the first of the coal-tar colours. Since that date the progress of artificial colour making has been so rapid, and the application of the new dyes made so simple, that it now seems doubtful whether many of the older dyestuffs and processes can continue much longer in use. The experience acquired in dyeing with any colouring material must not be undervalued on account of its partial disuse; and some illustrations, though of less practical importance than they were lately, may here be given, in describing the general principles of dyeing.

Assuming that the textile material has been subjected to the cleansing and whitening operations described under BLEACHING; that the water is soft and clear, and the vessels free from rust and perfectly clean, the next point to consider is the nature of the fibre. Very often if this is of animal origin, such as silk or wool, a simple immersion in a bath containing the colour will dye the fabric; but colour so applied to a vegetable substance as cotton, linen, or jute, would be easily washed away. The fibre in the latter case requires some special preparation to make the dye adhere, and a mordant is employed for this purpose. Mordants are usually mineral salts applied to the yarn or cloth, so as to leave their bases in intimate contact with the fibre. A class of mineral colours may be first described, as their production depends on simple reactions similar to those occurring in the use of mordants. One of these colours, chrome yellow, has been already noticed under CALICO-PRINTING. They are the result of an interchange of the bases and acids of two soluble salts in the material of the fibre, one of the new salts being soluble and readily washed out, the other insoluble and the substance having the colour.

Prussian blue (q.v.) may be taken as an instance of this mode of dyeing. A bath to dye 7 lb. of silk is made up as follows: 10 gallons water; 24 oz. nitrate of iron solution, specific gravity 1·6; 4 oz. stannous chloride. And another bath with 10 gallons water; 6 oz. yellow prussiate of potash; 3 oz. sulphuric acid. The first bath has a temperature of 130° F. The silk is turned through it till it is thoroughly penetrated with the liquor, then washed, and transferred to the second bath, which is also warm. The silk, without washing, is returned to the first bath, after which it is again washed and placed in the second bath. The first bath is now strengthened with 6 oz. of nitrate of iron and 2 oz. of stannous chloride, and the second bath with 3 oz. of sulphuric acid and 2 oz. of yellow prussiate of potash. Once more the silk is returned to the first bath, washed, and transferred to the second bath. After this steep, it is wrung out and left for six hours, when it is washed, raised, and dried in the air.

There are several things to be learned from this process. (1) The solutions must be dilute; (2) several operations are required to get an equal shade; (3) an acid solution is necessary to prevent iron oxide from depositing on the cloth, and this is made more certain by strengthening it in the last dipping; and (4) time is given for any action of the air before the final washing is given to the dyed silk. These or similar matters require attention in dyeing generally.

Buff is produced on cotton by a bath of nitrate of iron, followed by one of dilute and clear lime water, washing and drying. In this case peroxide of iron is left in the fibre, and forms the colouring material; the nitrate of lime being readily soluble in water, washes out. This is an instance, however, in which the cloth has been mordanted as well as dyed, and if we wish to give it, say, a black or dark purple colour, it only requires to be immersed in a bath of logwood.

Supposing that in place of nitrate of iron we had used a solution of alum or other soluble salt of alumina, as the sulphate (alum cake) or acetate (red liquor), we should have had the hydrate of alumina deposited in the fibre. As, however, this is simply white, the appearance of the cloth would not have altered; but if placed in a logwood bath, a pink or red colour would be the result, the tint and depth varying with the strength of the solutions. In such a case the cloth is dyed with an aluminous mordant.

The mordants most largely used are the salts of iron, alumina, and tin. Acetates and sulphates of both oxides of iron, as well as of alumina, and the two chlorides of tin and stannate of soda, form the greater portion of the materials employed.

Suppose that cloth is impregnated with acetate of iron, which is a combination of the peroxide of iron with acetic acid. This oxide is a feeble base, and the acid is volatile. Consequently, when the cloth is placed in a hot chamber filled with moist air, the acetic acid is expelled, and the oxide of iron is left in the fibre, which is what the dyer requires. The application of the acetate of alumina as a mordant is explained in the same way.

In the case of salts with non-volatile acids (nitrate of iron or sulphate of alumina, for example), lime-water, caustic soda, carbonate of soda, or similar bodies are used to precipitate the mordants in the material to be dyed, as in the instances given above. But in some kinds of dyeing the assistance of an alkali is not necessary to decompose the salt, as merely boiling it with the fibre is sufficient to separate the base and liberate the acid, the cloth retaining the former, and the latter adding to the acidity of the bath. If fresh alumina were added to the bath to combine with the liberated acid, the process could go on indefinitely, but when a certain amount of free acid has accumulated, the fibre ceases to effect the decomposition of the salt. In practice this is not the method followed, but a potash salt of an organic acid is added to the bath, the potash of which neutralises the strong mineral acid; the weaker organic acid being set free, which has not the same power of preventing the absorption of alumina by the fibre. Tartar or argol (impure acid tartrate of potash) is much used along with alum for wool-mordanting, and also in silk-dyeing with tin mordants.

Several salts of tin are much used as mordants—the most important being stannous chloride or muriate of tin—also called 'tin salts' and 'tin crystals.' Stannic chloride or perchloride of tin is likewise used, and a solution of the metal in hydrochloric and nitric acids, called 'tin spirits' and 'oxymuriate of tin,' is in general use. The latter is a mixture of stannous and stannic salts, and requires very great care in its preparation. The salts of tin are decomposed readily by the fibre, and the tin spirits require to be used when freshly made, as deposits soon appear in the solutions. Stannate of soda is also much employed in dyeing. When the fibre is charged with it, the insoluble stannic acid is liberated with dilute sulphuric acid.

The mordants mentioned above are employed chiefly in cotton-dyeing with the vegetable dyes or the similar artificial alizarin colours. Wool and silk are not usually mordanted in the manner described, and the following observations apply to cotton and other vegetable fibre.

Often, in dyeing, copper boilers are used with an ordinary fireplace for heating them. The dyestuffs are used either in powder or raspings among the water, or their extracts are employed. The dye solutions are generally warm or boiling, and the goods immersed in them require to be kept in constant motion, or nearly so, to insure uniformity of absorption.

Dyeing of Cotton.—The following is a brief outline of the processes in use for a few important colours:

Black is produced by steeping the goods in a decoction of sumac; then passing them through a solution of acetate of iron. After washing, they are next passed through a decoction of logwood.

Brown is usually obtained by passing the cloth through a decoction of cutch or Catechu (q.v.), and afterwards through a solution of bichromate of potash. Logwood, fustic, or any of the red colouring stuffs, can be afterwards added according to the shade of brown wanted.

Purples and lilacs are got from logwood and alizarin with mixtures of iron and alumina. With madder colours, reds and pinks are got by the use of alumina and tin.

Reds are also got from various dyewoods, as sappan-wood, peachwood, barwood, &c., with tin or alumina, the cloth being first soaked in an astringent, as sumac or gall-nuts. The coal-tar colours, safranine, &c., have almost entirely superseded these woods in the dyeing of reds.

Yellow is got from fustic, quercitron bark, Persian berries, &c., with tin or alumina mordants. Better shades of yellow are now, however, produced by auramine and other coal-tar dyes. Blue colours are not obtained from the natural dyeing materials with the usual mordants, and green is produced by dyeing a yellow such as fustic over cloth already rendered blue.

The production of Prussian blue on silk has been fully given, and the same method is applicable to cotton. For the dyeing of indigo blue.

Turkey-red is a very bright and permanent colour on cotton, obtained till recently from madder, but now almost entirely from alizarin, by a special process in the treatment. An oil mordant, as it is termed, is employed in combination with the fibre. Formerly a coarse olive-oil was made into an emulsion with a weak solution of crude pearl-ashes, through which the cloth was passed, then wrung out and hung up in a stove. The oil absorbs oxygen, and thickens into a varnish containing free fatty acids. The operation was repeated six or eight times. A Turkey-red oil is now sold which is chiefly the oleic acid of castor-oil in combination with ammonia or soda, and of this oil the cloth requires only one or two applications. The cloth is also mordanted with alumina as usual, and then passed into the dye-bath, which is gradually raised to boiling. The bath may be charged with ground madder, natural alizarin, or the artificial product, and generally sumac or some substance containing tannin is added. The goods are brightened by boiling in soap solution, and finally in a bath of tin spirits.

In dyeing cotton with coal-tar colours (with the exception of the azo group), the goods are first mordanted by passing them through a solution of tannic acid, and then through one of tartar emetic; or they are first passed through a decoction of sumac, and afterwards through a solution of stannate of soda. The goods are usually put into the dye-beck in a cold state, and gradually raised to a heat of about 120° F. as the dyeing proceeds. With the azo group of colours (see below) no previous mordanting is required, but a little sulphate of soda or common salt is added to the dye-beck to make the colour go on more evenly. These azo colours are dyed at a boiling heat. The reds of this group are not very satisfactory on cotton.

Aniline black is produced on cotton yarn directly by the oxidation of aniline with bichromate of potash and hydrochloric acid.

Dyeing of Wool.—This fibre absorbs both colours and mordants so much more readily than cotton, that for the most part the methods of dyeing it differ from those that have been described. Sulphuric acid has little action on wool as compared with cotton, consequently many operations in wool-dyeing are conducted in acid solutions at high temperatures, where cotton would be destroyed. An instance of producing a Prussian blue on worsteds may be given: 'Worsted, 100 lb. Make cold solutions of 9 lb. red prussiate of potash, 2½ lb. tartaric acid, 2½ lb. oxalic acid, and 2 lb. tin composition. Pour these together and add the mixture so produced to about 300 gallons of water at 100° F., and further add 12 lb. good oil of vitriol. Enter the goods, turn well, heat up slowly to the boiling-point, and boil for half an hour.'

Here it will be seen no salt with an iron base is present to form a Prussian blue, and consequently this constituent must be got from the decomposition of the red prussiate by the oil of vitriol, the wool absorbing the colour as it is formed. A blue produced in the way already given for silk would be comparatively cheap, but none of the mineral colours obtained by the mutual interchange of acids and bases in the fibre are successful with wool. Wool is dyed to a much larger extent than either cotton or silk with dark colours, and for these logwood and the astringent dyes catechu, nut-galls, sumac, &c., are chiefly used along with indigo, alizarin, and fustic for special shades. The wool is first, as a rule, boiled with bichromate of potash, sulphate of copper, and oil of vitriol, then with the dyes—for instance: 'Black. For 55 lb. wool. Boil with 17 oz. each chromate, bluestone, and oil of vitriol for 1½ hour. Dye in 22 lb. logwood and 4 lb. fustic, boiling 1 hour.' Sometimes the chromate is mixed with tartar for the first treatment of the wool, with or without sulphuric acid. Woaded blacks are the best for woollen cloths. By this method the wool or cloth is first dyed in the indigo vat a light or medium shade. It is then dyed a chrome black by a process the same or similar to that just given in which bichromate of potash and logwood are the chief ingredients used.

Generally when dyes on wool are required to stand milling (see WOOLLEN MANUFACTURE), the goods are first mordanted by boiling them for an hour in a solution of bichromate of potash and tartar. Brown, olive, drab, and similar colours are dyed with madder or alizarin, camwood, fustic, and logwood, in proportions varying with the shade required.

Until quite recently, the most important of the materials for dyeing wool, next to indigo, was cochineal. It gives with tin and alumina mordants very brilliant pinks, crimsons, and scarlets. To produce scarlet the cloth is boiled in tin spirits—generally with addition of cream of tartar—until mordanted with stannic oxide, then washed and boiled in the ground cochineal till the solution gets colourless, that is, till all the dye is absorbed. A second boiling is given with cochineal mixed with a little more mordant and tartar. Benzidine reds are now replacing cochineal.

With coal-tar dyes almost every conceivable colour can be obtained on wool. In most cases it is only necessary to add a little sulphate of soda and sulphuric acid to the dye-beck, no previous mordanting being necessary. Tin spirits and tartar brighten a number of the colours.

In dyeing wool, alizarin blue solution is said to give beautiful deep blue shades, as fast as indigo to light and milling, and is regarded as a great success as a substitute for the natural dyeware; artificial indigo is as yet too expensive a competitor.

Silk, when dyed dark colours, may be used without the same bleaching operations for the removal of the gum, required for brighter tints. The dyes and mordants for these are much the same as for wool, but the baths are usually hot soap solutions containing the dyes. Cochineal gives a poppy red with a tin or alumina mordant, and annotto in alkaline solution an orange yellow with the latter. Archil and safflower give violets and pinks without a mordant, but they are fugitive.

Silk is dyed with the coal-tar colours by a simple immersion in a solution in water or, if necessary, in spirit. Usually the soap solution of the silk gum is taken, and the colour brightened by rinsing in acetic acid. For the oxyazo dyes sulphuric acid is added to the bath.

DYESTUFFS.—The principles of the art of dyeing being already stated under the head of DYEING, it is only necessary to notice here, in the first place, the more important of the older dyestuffs of commerce, and then to give some account of the remarkable group of artificial dyes known as the 'coal-tar colours.' The first of these was introduced in 1856, and the number of them now in use is considerable. Still many of the older colouring materials to a large extent hold their ground, and it is by no means certain that they will ever be entirely displaced by purely chemically prepared dyes. Natural dyestuffs are chiefly products of the vegetable and animal kingdoms.

Vegetable dyes are obtained from all parts of plants, such as the roots, the wood, the bark, the leaves, the flowers, and the seeds or fruits. That is to say, of certain plants one or other of these is the dye-yielding part, but sometimes the whole plant is employed. The number of plants which yield colouring materials such as could be applied in the tinctorial arts is very great, and if we include those employed by savage races, the number of these dyestuffs actually used is still large. Those, however, which are well known are not very numerous. A fuller account of a few of the more important of those noticed below is given under their separate heads.

Madder (q.v.), from the root of *Rubia tinctorum*, has been used for dyeing red and for producing, along with other dyes and with certain mordants, compound colours since ancient times. Until the discovery of a process of making artificial *Alizarin* (q.v.)—the chief colouring principle of madder—it was largely cultivated in the Levant. Madder, and not artificial alizarin, is still used for dyeing calico in Persia and some parts of India, but a comparatively small quantity is now brought to western Europe. There are other two species of Rubia yielding dyes somewhat resembling madder which are employed in India. These are *R. cordifolia* and *R. sikkimensis*, the dye from the former being called 'manjit' or Indian madder.

Garancine is a red dyestuff prepared by treating spent madder with sulphuric acid. It is of less importance now than formerly.

Safflower, from the flower-heads of *Carthamus tinctorius*, yields both a red and a yellow dye, but it is only the former that is useful. The red, or rather pink, is a beautiful, though not a permanent, colour applied to the dyeing of silk, and more sparingly to cotton. It is a costly material, and before the introduction of aniline colours, the cultivation of safflower was an important industry in India.

Brazil-wood (q.v.), obtained from one or more species of Cæsalpinia, according to some authorities from *C. braziliensis*, according to others from *C. echinata*. Peachwood and Lima-wood are probably mere varieties, and the colouring matter from all three is supposed to be identical. These red-woods, as they are called, are chiefly used for cheap calico prints, and to some extent for dyeing silk.

Archil (q.v.) and *Cudbear* (q.v.) are dyes prepared from lichens. The colouring principle in each appears to be the same, and in fact there is no essential difference between the two stuffs. Archil is of a purple colour, and is most useful, along with other colouring matters, in the dyeing of wool various shades of brown and chocolate.

Panama Crimson.—This dye is used by the natives of the Isthmus of Panama for dyeing their straw-hats a fine crimson tint, which is said to withstand in a remarkable manner the action of sun and rain. It is obtained from a vine, but is scarcely known in commerce.

Chrysammic acid is a dye obtained by treating Aloes (q.v.) with nitric acid. From it a purple can be obtained on silk, black on wool, and pink on linen. It can be used with advantage along with aniline dyes.

Barwood and *Camwood* (q.v.), which are produced by the same tree, are employed in the ground state along with proper mordants for dyeing wool quiet reds and reddish browns; also for producing an imitation of Turkey-red on cotton. On wool the colours are permanent, but the dye on cotton is less so.

Quercitron.—From the bark of *Quercus tinctoria* a useful yellow dye is obtained. An extract of this bark called 'flavine' is used by woollen-dyers. Quercitron bark is most largely used as the yellow part in compound colours.

Fustic (q.v.).—There are two dyestuffs called by this name; the one is 'young fustic,' and the other 'old fustic.' The latter is the produce of *Morus tinctoria*, a large tree growing in Central America, and is the more important. The wood of this tree is ground, or an extract of it is made, and used like quercitron bark in the dyeing of compound colours on wool and cotton, for which it furnishes the yellow part.

Persian Berries, the fruit of *Rhamnus infectorius*, and perhaps other species. They are known also as Yellow Berries, French Berries, and Turkish Berries. The fruit is not much larger than a pea. The dye is employed for wool, but most largely in the printing of calico as the yellow part in such colours as green or orange. A decoction of the berries is made. The colour obtained is bright, but not very permanent.

Turmeric, the root of *Curcuma longa*, a plant largely cultivated in South Asia. It is rich in yellow colouring matter, which is, however, very fugitive. It is one of the few dyes which will fix itself on vegetable fibre without the help of mordants. Turmeric is largely used for colouring test-paper for chemical purposes, but its use as dye for textiles is falling off.

Annatto or *Arnotto* (q.v.), a preparation from the seeds of *Bixa orellana*. It produces a buff colour upon cotton, and a flesh colour upon silk, no mordants being required. The colours obtained from this dye are fugitive. The chief use of it is to improve the appearance of other dyed colours.

Indigo (q.v.) is obtained from two or three species of Indigofera, chiefly *I. tinctoria*. The indigo-plant is found wild over most parts of India, but generally near places where it has been cultivated. In that country the plant is extensively grown, there being two sowings in the year. It is cut just as the flowers begin to appear. The process of extracting the dye consists in steeping the plant for twelve hours, or rather more, in a vat with water, after which it is transferred to another vat where men agitate the liquid with sticks, thereby effecting the oxidation of the green colouring matter into blue particles of indigotin, which settle down as a sediment. This is next boiled for five hours and repeatedly passed through a strainer, by which the dye-particles are separated. After drying, the dye is pressed into slabs 3½ inches thick, from which the cubes of commerce are cut. For other plants from which indigo can be obtained, see INDIGO. This dye is one of the oldest known, and is still largely used for the dyeing of wool and cotton.

Woad.—This is believed to be the blue dye with which the ancient Britons stained or coloured their skins. It is obtained from the leaves of the cruciferous plant *Isatis tinctoria*, which has been long cultivated in Great Britain. In England woad is still used along with indigo in the dyeing of wool, but it is no longer employed in France or Germany.

Logwood (q.v.).—This well-known dyestuff consists of the heart-wood of *Hæmatoxylon campechianum*, a tree indigenous to Central America. Applied in small quantity to textile materials, the colour which logwood gives to them is a fugitive blue. At some places on the Continent it is used along with a mordant containing a large proportion of alum to dye wool a blue colour. It is employed to some extent as the blue part of compound colours in the dyeing of cotton, but the chief use of logwood is in the production of different shades of black on cotton and wool, for which suitable mordants are necessary. This dye stands best when applied in large quantities for dark colours.

The following vegetable dyes are of some importance in India, a few of them being also used in Europe: Sappan-wood (*Cæsalpinia Sappan*) yields a red colour; Sanders-wood (*Pterocarpus santalinus*), a pink; Catechu (q.v.) (an extract of *Acacia Catechu*), browns, drabs, and grays; the roots of *Morinda citrifolia*, a useful red; the twigs of *Strobilanthes flaccidifolius*, Assam indigo; the fruit-rind of the pomegranate (*Punica granatum*), a yellow; and the powder called 'kamala,' from the fruit of *Mallotus philippinensis* (otherwise called *Rottlera tinctoria*).

Several plants, either indigenous or naturalised, in Great Britain yield dyes. Among others, weld, the stalks of *Reseda luteola*, was used for dyeing yellow up to recent times. Dyer's Broom (*Genista tinctoria*) also yields a yellow colouring matter. From *Rhamnus catharticus* and *R. frangula* green and yellow dyes are obtained. The cultivation of the common yellow bedstraw (*Galium verum*) for red and yellow dyestuffs was at one time attempted.

The following are the chief dyes derived from animal substances:

Cochineal (q.v.), obtained from the insect *Coccus cacti*, is the most important red colouring matter for animal fibres. See above.

Kermes.—A colouring matter which, though not obtained from the same insect, is identical with cochineal. Several species of Coccus, of which the most common is *C. ilicis*, yield kermes. This dyestuff is chiefly employed for dyeing woollens and leather in the countries of which the insect is a native—viz. Spain, Turkey, Morocco, and the south of France.

Lac-dye.—In the washing of stick-lac (see LAC), the colouring matter secreted by the lac insect (*Coccus lacca*) is dissolved in the water, and recovered by boiling down the washings. The red dye is then made up in the form of small cakes. Lac-dye usually produces duller red colours than cochineal, but from a pure extract of it the same, or very similar, colours are obtained. It is still used as a dye in India, but very little now in Europe.

Murexide.—This beautiful and delicate purple dye, prepared by the action of dilute nitric acid upon uric acid and treatment of the product with ammonia, was largely used in 1855 and 1856 for dyeing wool and silk, and for printing upon calico. The uric acid required for its production was got from guano. Murexide had only been tried for a year or two when its manufacture was rendered unprofitable by the introduction of aniline colours.

The only mineral dyes of much importance are *Prussian Blue* and *Chrome Yellow* (q.v.). The method of producing the former is given under DYEING.

Coal-tar Colours.—The dyes now manufactured from products obtained in the distillation of coal-tar are extremely numerous, and new ones are daily added to the list. With the exception of anthracene, from which artificial alizarin is prepared, the raw materials chiefly used are the naphtha or benzene and carbolic acid; naphthalene, a crystalline solid body, has lately been coming much into use as well, more especially for dyes competing with cochineal. These substances, although not constituting a large percentage of the tar, are more than sufficient in amount for any supply that could be required, the quantity of tar from the gas-works in Great Britain alone being nearly half a million tons per annum. The total annual value of these colours produced in England, Germany, and France is about £4,000,000.

The rapid development of this industry is the result of the progress of organic chemistry, and these dyes can only be understood and classified from a chemical point of view. Leaving out artificial alizarin and indigo at present, these colours may be arranged in three divisions: (1) *Aniline Dyes.*—These are compound amines, bodies of the nature of bases. (2) *Phenol Dyes.*—These are derivatives of carbolic acid or phenol and similar chemical bodies, and have more or less acid properties. (3) *Azo Dyes.*—These are bodies containing azote or nitrogen connecting two groups, and may be neutral, but the groups may also be either of a basic or acid nature.

1. *Aniline Dyes.*—The preparation and properties of aniline have been described under that head. A base of the same series, toluidine, and another from naphthalene, are used along with it for certain colours. The method of preparation for all these bodies is nearly alike—viz. by the action of nascent hydrogen on the requisite nitro-compound and distillation of the product with soda. Iron filings and hydrochloric acid are generally taken to obtain the hydrogen.

When a mixture of aniline and toluidine is heated with arsenic acid for several hours to a temperature of about 380° F., a mass is left from which rosaniline is separated, the compounds of which chiefly form the aniline dyes. Stannic chloride can be used in place of arsenic acid, but the latter gives better results; careful attention is required in the separation of arsenic from the dyes. The residue after cooling is powdered and treated with boiling water, which dissolves arseniate and arsenite of rosaniline, and leaves a residue containing other colouring matters. When the solution has common salt mixed with it, double decomposition takes place, and the arsenical salts remain in solution, while rosaniline as hydrochloride is precipitated. This substance is not insoluble in water, but in water containing salt it is precipitated or 'salted out.'

The mixture of bases treated, called 'aniline oil,' combine with oxygen from the arsenic acid, which removes hydrogen in the form of water, the residues coalescing into the more complex molecule of the colouring matter. Another process—the one now chiefly used—for the preparation of rosaniline is heating aniline with nitrobenzine, protochloride of iron, and iron filings; in this case the oxygen is derived from the nitrobenzene. The residue is treated as in the previous process. The product is purified by crystallisation from water, and the hydrochloride of rosaniline so obtained is the colour magenta.

Rosaniline itself is colourless, and crystallises in needles or plates. It separates from magenta on adding soda to its solution, not being very soluble in water; it dissolves more readily in alcohol. It forms salts with acids, and these are the aniline red dyes. Magenta, or fuchsine, is chiefly hydrochloride, roseine the acetate, azaleine the nitrate, but pure simple salts are not usually sold. The salts have usually a green metallic lustre, and red in thin plates by transmitted light. The solutions have an intense crimson colour, and are not fluorescent.

Rosaniline is accompanied, as usually manufactured, by an almost similar substance—pararosaniline. The difference is that of homologues of the same series, and as pararosaniline is the lower, we shall use it in the following comparative formulæ, showing the replacements producing the various colours.

Methane (marsh-gas), CH_4, is the simplest of a series of hydrocarbons, and contains 1 atom of carbon and 4 of hydrogen. The hydrogen atoms may be replaced one after another by various elements or compound groups. In chloroform 3 are replaced by chlorine, giving the formula $CHCl_3$; and if this body, under certain conditions, acts on benzene, C_6H_6, we get hydrochloric acid and a hydrocarbon named tri-phenyl-methane.

$$CHCl_3 + 3C_6H_6 = C(C_6H_5)_3H + 3HCl.$$

The substitution products, or their compounds, derived from this hydrocarbon are the various aniline dyes.

By treating tri-phenyl-methane in the same manner as benzene is treated to get aniline, we get a tri-amido base termed paraleucaniline. By the addition of an atom of oxygen to this body we get pararosaniline, which by solution in acids, as already stated, forms the aniline reds. The following are the respective formulæ:

Tri-phenyl-methane.	Paraleucaniline.	Pararosaniline.
$C\left\{\begin{array}{l}C_6H_5\\C_6H_5\\C_6H_5\\H.\end{array}\right.$	$C\left\{\begin{array}{l}C_6H_4 \cdot NH_2\\C_6H_4 \cdot NH_2\\C_6H_4 \cdot NH_2\\H.\end{array}\right.$	$C\left\{\begin{array}{l}C_6H_4 \cdot NH_2\\C_6H_4 \cdot NH_2\\C_6H_4 \cdot NH_2\\OH.\end{array}\right.$

Aniline Blue.—When the hydrogen atoms in the amido groups (NH_2) become replaced in pararosaniline by phenyl, C_6H_5, methyl, CH_3, ethyl, C_2H_5, or similar groups, the aniline blue colours are produced. The ordinary spirit soluble blue has an atom in each of the amido groups replaced by phenyl, and is the hydrochloride of triphenylated pararosaniline, and has the following formula:

$$C\left\{\begin{array}{l}C_6H_4N\begin{array}{l}-C_6H_5\\-H\end{array}\\C_6H_4N\begin{array}{l}-C_6H_5\\-H\end{array}\\C_6H_4N - C_6H_5 \cdot HCl.\end{array}\right.$$

This blue is obtained by heating rosaniline to a high temperature with a large excess of aniline along with some benzoic acid—the action of which is not understood. Ammonia is formed during the operation, and escapes along with the excess of aniline, which is distilled off. When the action ceases, the product is cooled, and excess of hydrochloric acid added, which forms an insoluble compound of the base, giving, when washed and dried, the spirit blue.

It will be seen by the formula that there are still two free atoms of hydrogen in the amido groups. These can be substituted by methyl or ethyl, and blues of a purer shade obtained. All the varieties are only soluble in spirit, and to a small extent; they give very pure blue colours.

Soluble Blue.—The spirit blue, so called from being insoluble in water, is to a large extent converted into a compound soluble in water, termed 'soluble blue,' thereby giving it a much wider range in its application. The compound is a sulphonic acid salt, and is prepared in the usual manner by mixing with sulphuric acid, gently warming, and after a time pouring the mixture into cold water, in which the free acid is insoluble. After washing, it is cautiously dissolved in soda solution, and salted out. It is then dried gently, forming a brownish cake. It dissolves readily in water. This is monosulphonate of the dye, and called alkali blue.

Water Blue or *Cotton Blue* is a trisulphonate, and is prepared by longer heating at a temperature a little over 212° F. The excess of sulphuric acid used is separated from the solution by milk of lime, this sulphonic acid being soluble in water. It is converted into a soda or ammonia salt.

Methyl Violet.—If five of the amido-hydrogen atoms in rosaniline are substituted by methyl, this colour is produced. The methyl groups are substituted in the aniline, and the process of oxidation is then nearly the same as in the preparation of magenta. Pure di-methyl-aniline is treated with chloride of copper, and some common salt is used to moderate the action. After the mass is cold it is carefully treated with water, to form a strong solution of the salt, in which the colour is insoluble. After the salt is carefully drained off, the colour is dissolved in water and any copper removed by sulphuretted hydrogen. The salt or form in which this colour is sold is often a double chloride of the colour base with chloride of zinc, which is crystalline. The double zinc salts are frequently used for a similar purpose, as they crystallise readily, giving the product a definite form and appearance, and the oxide of zinc is readily soluble in acids and in caustic alkalies, and having no colour does not interfere with the dyes.

Benzyl-rosaniline Violet.—The methyl groups in the violet described can be replaced by heating the colour with the chloride of benzyl, a body prepared with toluidine, the benzyl group, C_7H_7, producing a bluer colour.

Malachite Green.—This is a colour belonging to a class having only two amido groups in tri-phenyl-methane. The formula will best illustrate its structure. That of brilliant green is also given.

Malachite Green.	Brilliant Green.
$C\left\{\begin{array}{l}C_6H_5\\C_6H_4 \cdot N(CH_3)_2\\C_6H_4 \cdot N(CH_3)_2\\OH.\end{array}\right.$	$C\left\{\begin{array}{l}C_6H_5\\C_6H_4 \cdot N(C_2H_5)_2\\C_6H_4 \cdot N(C_2H_5)_2\\OH.\end{array}\right.$

In malachite green 4 hydrogen atoms are replaced in the amido groups by methyl, and in brilliant green by ethyl. These colours are chiefly sold as zinc double salts or oxalates. They generally have a rich metallic lustre, and are readily soluble in water.

Helvetia green and others are sulphonic acid derivatives of these colouring matters.

2. *Phenol Dyes.*—When the hydrogen atoms of benzene are replaced by hydroxyl, OH, bodies of an acid or semi-acid kind are formed, called phenols. These are mono-acid, di-acid, &c., according to the number of hydrogen atoms substituted. This is seen in the following formulæ:

Benzene	C_6H_6;
Phenol, carbolic acid	$C_6H_5(HO)$;
Resorcin, di-hydroxyl-benzene	$C_6H_4(HO)_2$;
Pyrogallic acid	$C_6H_3(HO)_3$.

Naphthalene yields the most important bodies of this class, called naphthols. A general method for their preparation is to melt the sulphonic acid of the hydrocarbons with caustic soda, and add to the solution of the residue an excess of hydrochloric acid, which separates the phenol.

Some of the important yellow dyes are nitro compounds of these bodies. They are got by cautiously mixing the phenols with strong nitric acid, and generally finishing with the aid of heat. Practically better results are got by first forming the sulphonic acid.

Picric Acid is tri-nitro-phenol. Its formula is $C_6H_2(NO_2)_3OH$. It is sparingly soluble in water, to which it gives an intensely bitter taste, recognisable in fibres which have been dyed with it. It crystallises in thin yellow laminæ. The salts form fine crystals, and are more or less explosive.

Naphthol Yellow, Martius' Yellow.—This is di-nitro-naphthol, and was the first colour of value made from naphthalene. It is insoluble in water, but gives fine yellow or orange coloured salts, crystalline and soluble in water. They closely resemble the picrates. A sulphonic acid of this yellow is also used as a dye.

Rosolic Acid, Aurin.—If tri-phenyl-methane contained phenol instead of amine groups, as in rosaniline, it would represent these dyes. In fact, the rosolic acids and rosanilines are convertible into each other. These dyes are now of little importance in practice.

Phthaleins.—These form a very important class of dye-yielding materials, and are formed by the union of phenols with the anhydride of phthalic acid. Phthalic anhydride is obtained from naphthalene by first forming a chlorine addition product, and then oxidising with nitric acid. Crude phthalic acid so obtained is converted into water and the anhydride of phthalic acid (which is volatile) by heating.

Gallein was the first discovered of these colours, and was produced by heating pyrogallic acid with the anhydride. It is chiefly made into cerulein.

Cerulein is obtained from gallein by heating with sulphuric acid to 400° F. till the colour changes to brownish-green, then, on cooling, mixing with a large quantity of cold water. The treatment has removed an atom of water. The cerulein forms a blackish powder. It is insoluble in water, but dissolves in alkalies with a beautiful green colour.

Fluorescein, Eosin.—This is the resorcin phthalein, and is prepared by heating the materials to 400° F. till water ceases to be given off. The mass remaining is fluorescein. From the remarkable fluorescence of its compounds it derives its name, and an alkaline solution of it is taken as a striking example of this phenomenon. It is slightly soluble in water, with a yellow colour, and in the dry state is a reddish crystalline powder.

Fluorescein itself is scarcely used as a dye. But when part of its hydrogen is substituted by bromine, chlorine, or iodine, the beautiful dyes called *eosins* are formed. The tetrabrominated eosin, or rather its potash salt, has been most largely used. It forms red crystals with yellowish-green reflections. The solutions are rose-coloured with intense green fluorescence. One of the most beautiful colours of this group is the replacement by 2 chlorine and 4 iodine atoms, called phloxine. Methyl and ethyl ethers of this body are also dyestuffs.

3. *Azo Dyes.*—The first section of the coal-tar colours consisted of aniline and similar bodies coalesced into more complex basic forms. The second of phenols, with substitutions yielding acid compounds. The third section, now to be considered, in its simplest form is neutral, but by reactions with amines (bases) or phenols (acids) can produce colouring bodies with the chemical properties of either of the other sections. This class is obtained by a reducing action on nitro compounds, leaving two residues in combination by the mutual affinity of the *nitrogen* atoms—hence the name, from azote (nitrogen). The construction will be understood from the following equation:

$$\underset{\text{Nitrobenzene.}}{2C_6H_5NO_2} + 4H_2 \quad = \quad 4H_2O + \underset{\text{Azobenzene.}}{C_6H_5\mathbf{NN}C_6H_5}.$$

We have here, it will be seen, simple phenyl groups combined with two nitrogen atoms, and from the absence of amido or hydroxyl groups, the substance is neither basic nor acid. If in place of nitrobenzene a nitro derivative of a different hydrocarbon had been taken, a corresponding azo compound would have been produced. The principal development of the coal-tar colours of late years has been connected with this reaction. It can be seen that by manipulating the hydrocarbon groups with amido and hydroxyl groups as with the bodies in the other sections of the colours, any number of azo dyes may be obtained.

Most of these dyes from benzene and the lower members of its series are yellow or brown, but when hydrocarbons with more carbon atoms are used, such as cymol and naphthalene, reds and blues are produced; some of the scarlets having almost displaced the colours from cochineal.

Bismark Brown, Phenylene Brown, &c.—This is an example of a colour with amido derivatives, and is selected as being the first of the azo colours having a manufacturing success. It is prepared by the action of nitrous acid on the di-amine of phenylene. The reaction is shown in the equation:

$$2C_6H_4(NH_2)_2 + HNO_2 = 2H_2O + NH_2{\cdot}C_6H_4NNC_6H_3(NH_2)_2.$$

These colours are very easily prepared; as a rule the colour precipitates when its components are brought together. Besides the dyeing of cotton and wool, this colour is much used for dyeing leather. It is used as the hydrochloride, a dark powder.

Fast Yellow is the potassium salt of a sulphonic acid. Its construction is seen by the formula:

$$KSO_3{\cdot}C_6H_4NNC_6H_4{\cdot}NH_2.$$

Oxyazo dyes are prepared with phenols, and have become the most important of the coal-tar colours. They are nearly all sulphonic acid compounds, and used in the form of soda salts of these acids. The yellow and orange colours are sold as Tropeolins; fast red, Roccellin; claret red, Bordeaux; scarlets, Biebrich, Crocein, &c. An example may be given of the composition of one of these colours, first known as Meister's scarlet, now sold as scarlet G:

$$C_6H_3(CH_3)_2NNC_{10}H_4(OH)(HSO_3)_2.$$

This dye is the sulphonic acid itself, but usually an alkaline salt is employed in the dyeing process, as the acids are more or less insoluble. A compound of the acids with alkaline bisulphites has lately been used with some success.

The benzidine and allied colours recently introduced belong to the tetrazo group of the oxyazo dyes. These have the valuable property of dyeing cotton without a mordant. Almost any shade of blue, green, yellow, and red can be obtained from them. They stand scouring and milling, and are considered fast to light on wool; but some, at least, are not permanent on cotton. There exists a strong belief that the benzidine colours will be those most largely made from coal-tar products in the future since they are so simply applied. See PHENYL COMPOUNDS.

Anthracene Dyes.—These are only a small group, and are regarded rather as artificial productions of the natural colours of madder than coal-tar colours. Artificial alizarin is now, however, manufactured on a large scale, and has almost completely taken the place of the natural product. In England it was first made in 1870. In the manufacture of these dyes anthracene is first converted into anthraquinone by oxidation with solution containing chromic acid, and then into sulphonic acid, or rather sulphonic acids, for there are several formed. This requires fuming sulphuric acid, and a temperature of 320° F. The acids are converted into soda salts, and may be separated by crystallisation. Mono-acid produces blue, di-acids more of the red and orange colours.

The soda salts of the sulphonic acids are now mixed with a small proportion of chlorate of potash, and heated under pressure with caustic soda to 400° F. for twenty-four hours. Water is added in sufficient quantity to keep the soda liquid, and the mixture requires to be constantly stirred, or the materials would not come together. The mass obtained is ground and dissolved in water neutralised with hydrochloric acid, when the alizarin separates. It is filtered and pressed.

Alizarin as sold contains three colouring matters—alizarin, giving blue; anthrapurpurin, red; and flavopurpurin, orange shades. They may all be produced separately from the different sulphonic acids. Their properties as dyes are similar.

Dynamo-electric Machines are machines for generating electric currents by means of the relative movement of conductors and magnets. Faraday discovered in 1831 that an electric current is induced in a conductor when it is moved across the pole of a magnet, so that it cuts the lines of magnetic force, or (more generally) whenever the number of these lines which passes through the circuit of the conductor is in any way varied. If, for example, a coil of wire, the ends of which are connected so that the whole forms a closed circuit, be suddenly withdrawn from the pole of a magnet, a transient electric current is induced in it, while the lines of magnetic force which proceed from the pole are ceasing to be present within the coil. If the coil be replaced, a current will again be induced, but in the contrary direction. Similarly, a transient current is induced if the coil be held at rest while the magnet is drawn away; or, again, if the coil be turned round so that the direction of the lines of force through it becomes reversed, in which case the effect will be twice as great as before. Any movement which causes an alteration to take place in the amount of magnetic induction through the coil produces a transient current, the electromotive force of which is proportional to the rate at which this alteration takes place. The whole amount of electricity produced is the same whether the movement be fast or slow. When the movement is slow, the current lasts longer in proportion as its strength is less. To produce the movement requires an exertion of mechanical work, which finds its equivalent in the energy of the induced current.

Faraday's discovery was immediately followed by the invention of numerous forms of magneto-electric machines, as they were then called, in most of which a steel horseshoe magnet was made to rotate over a pair of coils wound on a fixed armature, or the armature and coils were made to rotate while the magnet was held fixed. Fig. 1 is an example of one of these early forms, in which the armature, BB, with the bobbins, C, D, which consist of coils wound upon iron cores fixed to the armature, revolves in front of the magnet poles, N, S. In every half-revolution the lines of magnetic force through the bobbins have their direction reversed, and a series of transient currents are consequently produced in the coils. These pass to the external part of the circuit through the spring brushes, H, K, which make contact with a revolving collector, consisting of insulated metallic rings on the axle, to which the ends, *m*, *n*, of the coils are attached. If *m* were always in contact with H, and *n* with K, it is obvious that each successive transient current would take the direction opposite to its predecessor—the direction of the current would alternate at every half-revolution. On the other hand, it is easy, by splitting the rings, to arrange the collector so that H is in contact with *m* for

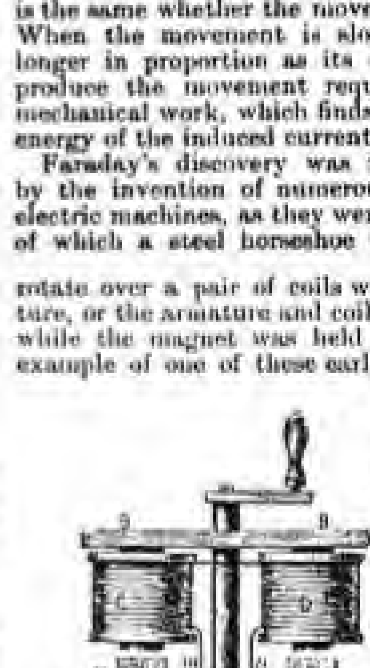


Fig. 1.

Fig. 2.

half a revolution, and then with *a* for the other half, while K is in contact first with *a*, and then with *a*, with the effect that the successive currents all have the same direction in the external portion of the circuit. The collector is then called a commutator. A common form of commutator is shown in fig. 2.

An ideally simple form of dynamo is represented diagrammatically in fig. 3, which represents a conductor consisting of a single loop of wire revolving in the magnetic field between the poles of a magnet, NS, so that at every half-revolution the lines of force have their direction of passing through the loop reversed, and a series of transient currents is consequently induced in the loop. Here, again, a commutator is required if the currents are to have one continuous direction in the external portion of the circuit. In the position sketched (by full lines), the side, *a*, of the rectangular loop is cutting the lines of force in one direction, and the side, *b*, is cutting them in the other, and both these movements are contributing to produce electromotive force in one direction round the loop; the other two sides (i.e. the front and the back) of the loop do not cut lines of force, and therefore do not contribute to the production of electromotive force. As the loop approaches the vertical position (shown by dotted lines), the component motion of the sides across the lines of magnetic force becomes reduced, and the electromotive force diminishes, till, at the vertical position, it disappears entirely, for there the sides of the loop are moving (at the instant) along the lines of force. After that they begin to cut the lines of force again, but in the reverse direction, and an electromotive force opposite to the last begins to act, which reaches its maximum when the coil is again horizontal. The same variations are repeated as the coil turns through the remaining half of its revolution. The strength of the current follows similar fluctuations, being determined by the electromotive force and by the resistance of the circuit, including the resistance of the revolving loop itself.

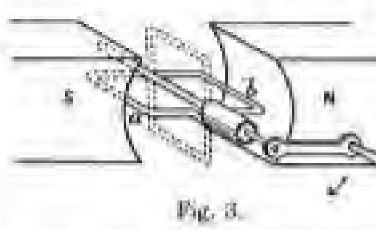


Fig. 3.

The effect of the revolving conductor in producing electromotive force may be increased (1) by increasing the speed of rotation; (2) by forming the loop with more than one turn of wire so as to make a coil, the whole effect is then the sum of the effects due to the individual turns; (3) by strengthening the magnetic field. One very important method of doing this is to furnish the revolving coil with an iron core, the effect of which is to increase the magnetic induction through the loop, across the space from pole to pole, by providing an easier path for the lines of magnetic force to cross this gap. In early dynamos the armature (as the revolving-piece is called) frequently consisted of a coil of many turns wound on an iron core, in the manner illustrated by fig. 4, which shows in section the simple shuttle-wound armature introduced by Siemens in 1856. The ends of the coil were brought to a commutator like that of fig. 2, and the effect was to produce currents which were uniform in direction. They were, however, very far from uniform in strength, varying from zero to a maximum twice in every revolution of the shaft.

Fig. 4.

In the early dynamos permanent steel magnets were used to produce the field in which the armature moved, but it was soon recognised that electro-magnets might be employed instead, and in 1863 Mr Wilde introduced a machine with large electro-magnets, which were excited by a small auxiliary armature revolving between the poles of a permanent magnet. Before this it had been proposed in machines with permanent magnets to supplement the magnetism when the machine was in action, by having coils wound upon the magnets, and by allowing the current produced in the machine itself to pass through these coils. It was not till 1867, however, that it became known that steel magnets were wholly unnecessary, and that dynamos with electro-magnets might be made entirely self-exciting. Even when the cores of the electro-magnets are of soft iron, there is enough residual magnetism to initiate a feeble current; this develops more magnetism, which in its turn develops more current, and so the process goes on until full magnetisation is reached. The principle of self-excitation was enunciated independently, and almost simultaneously, by Wheatstone, Werner Siemens, and S. A. Varley; it is now made use of in all except the smallest machines. The term 'dynamo-electric' was at first applied to distinguish these machines which were self-exciting from 'magneto-electric' machines, which had permanent magnets to give the field; but this distinction is no longer maintained, and the name 'dynamo' is now used in the wider sense defined above.

An extremely important step in the development of the dynamo was taken in 1870 by Gramme, who introduced a form of armature which, for the first time, gave a current not merely continuous in direction, but also sensibly uniform in strength. The Gramme ring armature is shown diagrammatically in fig. 5. It consists of a ring-shaped iron core, revolving in the magnetic field, and having a series of coils, A, B, C, &c., wound upon it. These are joined to one another in a continuous series, and also to the insulated segments of a commutator, *a*, *b*, *c*, which revolves with the ring, and from which the current is taken by brushes, H, K. Consider now the action of the field in producing electromotive force in any one of the coils, such as A. Near the place in which it is sketched, the coil A is moving in a direction parallel, or nearly parallel, to the lines of force, and, therefore, is having little or no electromotive force induced in it. But by the time the ring has made half a revolution, the same coil will have the lines of force within it reversed. Between these two positions, therefore, there must have been a generation of electromotive force, and this will in fact be going on most actively half-way between the two places. The coil C is at present the most active contributor of electromotive force, but B and D, the coils lying in front of and behind it, are also contributing a share, and the whole electromotive force between A and E, so far as that side of the ring is concerned, will be the sum of the several effects due to all the coils from A to E. A little consideration will show that the same action is going on on the other side of the ring, so that if the brushes be applied at *a* and *e* they will take off to the external portion of the circuit a current, half of which is contributed by one side, and half by the other side of the ring, the two sides acting like two groups of battery cells arranged in parallel and of equal resistance and equal electromotive force. The whole electromotive force in the armature is the same as that produced by the coils on one side alone, but the internal resistance is halved by the division of the current between the two sides. In actual Gramme armatures, the number of coils on the ring is very much greater than the number shown in the sketch, and each brush is made wide enough where it presses on the commutator to touch two of the segments at once. Hence the current is never interrupted, and the fluctuations in its strength, which occur as one segment passes out of contact and another comes in, may be made almost indefinitely small. As each coil passes, it is for the instant short-circuited through the brush, and this would give rise to a waste of energy in the coil and to sparking at the brushes, were it not that the brushes are set to bear on the commutator at the points where the development of electromotive force in the corresponding pair of coils is a minimum. These neutral points, as they are called, are not exactly midway between S and N, but are in advance of that position in consequence of the magnetic field within the ring being distorted through the action of the currents in the armature coils. Hence the brushes require to have what is called 'lead,' and this lead has in general to be adjusted whenever the output of the machine is considerably varied, more lead being needed if it happen that the armature current is increased while the field magnets remain of constant, or nearly constant, strength. The adjustment of the brushes is a matter of much practical importance in the management of a dynamo, for the sparking to which faulty adjustment gives rise speedily wears away the commutator bars as well as the brushes themselves.

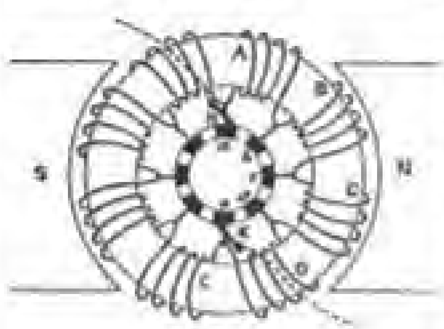


Fig. 5.

A small practical Gramme dynamo of an early form is shown in fig. 6. In this example two field-magnets conspire to produce a north pole at N, and other two to produce a south pole at S. The commutator is a series of copper bars mounted on an insulating hub fixed to the shaft, and separated from one another by thin stripes of mica or other insulating material; these bars have radial projections, which are soldered to the junctions of successive armature coils. Each brush consists of a flat bundle of copper wires pressed lightly against the commutator by a spring. The core of the armature is a ring made up of many turns of soft iron wire, on which insulated copper wire is wound to form the coils. It is essential that the core of the armature should not be solid, for in that case currents would be developed in the substance of the moving iron itself to such an extent as very seriously to impair the efficiency of the machine. Hence the core of dynamo armatures is always subdivided, by being made up either of wire, or more usually of thin plates more or less carefully insulated from one another. Fig. 7 shows the armature of a small Gramme dynamo, removed from its place between the pole-pieces.

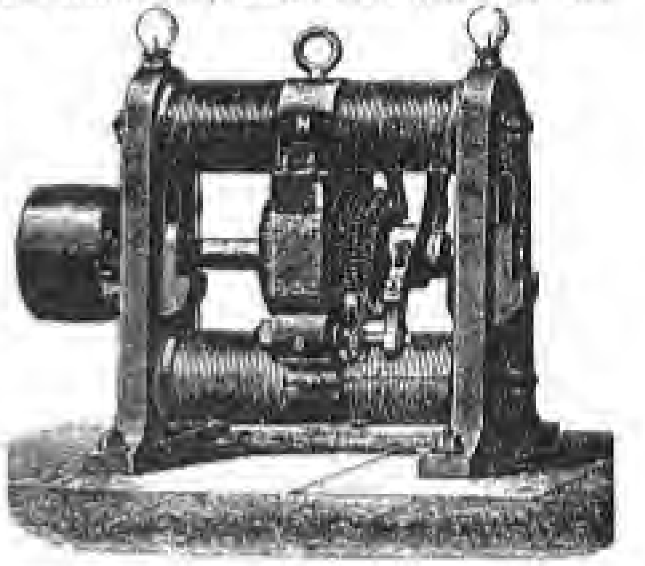


Fig. 6.

Fig. 7.

Two years after the introduction of the ring armature by Gramme, it was shown by Von Hefner Alteneck that the Siemens armature (fig. 4) might be modified so that it also should give continuous currents of practically constant strength. In the original Siemens armature there was but one coil, all wound parallel to one plane, and the current fluctuated from nothing to a maximum in every half-revolution. In the modified form the coil is divided into many parts, which are wound over the same core, but in a series of different planes, the plane of each successive coil being a little inclined to the plane of the coil before it. The coils are all joined in series, and their junctions are connected to the bars of a commutator just as in the Gramme ring. The Siemens-Alteneck or drum armature may, in fact, be compared to a Gramme armature, in which the coils, instead of being wound on successive portions of a ring, are all wound on one piece of core, preserving, however, the angular position they would have in the ring. Their action depends on their angular motion, and is therefore the same in both cases. As the drum revolves, that coil which is passing the neutral plane (viz. the plane perpendicular to the lines of force) is for the moment inoperative, and the brushes are set to touch those bars of the commutator that are connected with it. The other coils are more or less operative, the most active contributor of electromotive force being that one which is for the moment perpendicular to the neutral plane. The electrical effects in drum and in ring armatures are the same. Nearly all continuous current dynamos have one or the other; most makers prefer the ring type, mainly from considerations of convenience in construction; but the drum type holds its place in some of the best modern machines.

An important element in the classification of dynamos is the manner in which magnetism is induced in the field-magnets. These may of course be excited from an independent source of electricity; but when the machine is self-exciting, there are three important alternative methods. In the early machines the coils on the field-magnets were connected in series with the external part of the circuit, and consequently the whole current produced by the machine passed through both. This arrangement is distinguished as *series winding*, and is shown diagrammatically in fig. 8. It was first pointed out by Wheatstone, in 1867, that the magnet coils, instead of being put in series with the external conductor, might be arranged as a shunt to it, thereby forming an alternative path through which a portion only of the current would

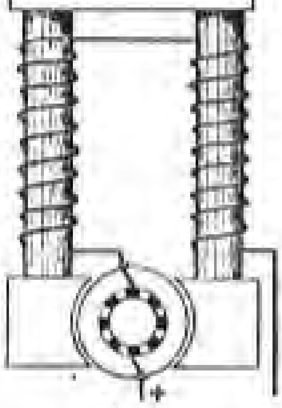


Fig. 8.

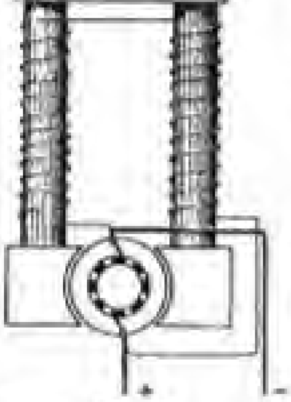


Fig. 9.

pass. In this arrangement, which is called *shunt winding* (fig. 9), the magnet coils consist of many turns of comparatively fine wire, so that they may not divert an excessive quantity of current from the external circuit. Finally, in *compound winding* (fig. 10) the two previous methods are combined. The field-magnets are wound with two coils; one of these (which is short and thick) is connected in series with the external circuit, and the other (which is long and fine) is connected as a shunt to it. This plan appears to have been first used by Varley in 1876, and afterwards by Brush, who pointed out that it, along with simple shunt winding, has the advantage of maintaining the magnetic field even when the external circuit is interrupted. It has, however, when properly applied, another and more important merit, as will appear below.

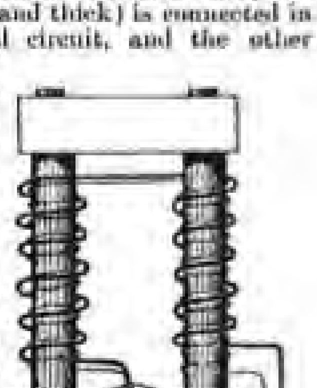


Fig. 10.

In a series-wound dynamo the magnets do not become excited if the external circuit is open, and become only feebly excited when the external resistance is high. Let the external resistance be reduced, while the armature is forced to turn at the same speed. The current will now increase, producing a stronger magnetic field; the electromotive force is therefore greater than before. A curve drawn to show the relation between the current and the difference of potential between the terminals of the machine (which is a little short of the full electromotive force, in consequence of the resistance of that part of the circuit which is within the machine itself) will in its early portion rise fast as the current increases, in consequence of the rapid augmentation of the magnetic field. Such a curve is called the characteristic curve of the machine, and is shown at AA in fig. 11.

If we continue to increase the current by further reducing the external resistance, the magnets tend to become saturated, and finally even have their magnetism somewhat weakened on account of the influence of the currents in the armature coils. Further, the loss of potential, through internal resistance, becomes more considerable. The difference of potential between the terminals accordingly passes a maximum, and becomes considerably reduced when the current is much augmented, as appears in fig. 11. The characteristic curve for a shunt-wound dynamo is shown at BB in the same figure. Here the strength of the magnetic field is nearly constant, but decreases a little when the machine is giving much current, partly because the current in the shunt circuit is then somewhat reduced, and partly because the current in the armature coils tends to oppose the magnetisation. Hence the potential falls off as the current increases. This fall will, however, be slight if the resistance of the armature is very low and if the field-magnets are very strong, and under these conditions a shunt-wound dynamo will give a nearly constant difference of potential whether much or little current be taken from it, provided, of course, that the speed remain unchanged. To make the difference of potential more exactly constant, it is necessary that the magnetic field should become stronger when the machine is giving much current, and compound winding achieves this. A compound-wound dynamo may be regarded as a shunt machine in which the action of the shunt winding is supplemented by that of a series coil on the magnets. When the machine is running on open circuit, the shunt coil alone is operative; as the current taken from the machine is increased, the series coil produces a larger and larger supplementary effect on the magnets, and by choosing a proper number of series windings, their effect may be made to neutralise with great exactness the droop in the characteristic curve which would occur if the shunt coil were the only source of magnetism.

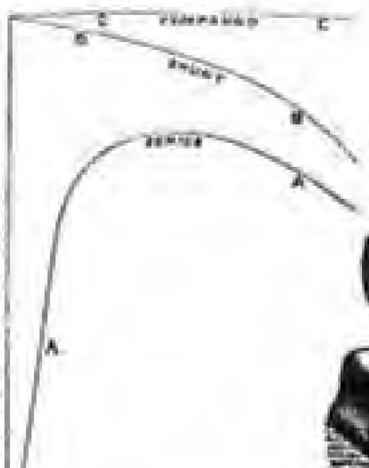


Fig. 11.

Compound machines wound for constant potential give a nearly straight horizontal line for their characteristic; CC in fig. 11 is an actual example. By making the series coil more influential, so that the potential at the terminals rises slightly as the current increases, the machine may be compound-wound to give constant potential at the ends of long leading-wires by which the current is conducted to a distance.

Series-wound dynamos are largely employed for electric lighting by arc lamps. Compound-wound machines are especially suitable for incandescent lighting, where the lamps are connected in parallel, and where it is important that the potential shall not vary when more or fewer lamps are in action. Shunt-wound machines are also largely used for incandescent lighting, the potential being adjusted to a constant value by varying the speed of the machine, or by throwing resistance into or out of the magnet shunt circuit. Shunt machines are the most suitable for charging storage batteries and for electro-plating, because of their not being liable to have their polarity reversed by a back current from the battery or bath.

Fig. 12 illustrates the Edison-Hopkinson dynamo, which may be cited as an excellent instance of modern construction. Here a drum armature is used, not a ring; and in this instance the armature coils, instead of being of wire as they are in smaller machines, are formed of copper bars insulated with mica, each pair of opposite bars being joined to form a loop, the ends of which are connected to opposite segments of the commutator, as well as to the loops which come next in order. The field-magnets are shunt-wound, and are set vertically with the pole-pieces at the bottom. Machines of this class are made of sufficient size to give a current of 660 ampères, with a potential of 105 volts; the output of electrical energy is therefore at the rate of 69,300 watts, or over 92 horse-power. There are five brushes on either side of the commutator, giving a large area of contact, and these are separately removable to allow of their being trimmed or cleaned while the machine is running.

In most dynamos the field-magnets are designed to form as simple a magnetic circuit as possible, with two poles which stand at opposite ends of one diameter of the commutator. In some cases four or more poles are used, spaced at equal intervals round the armature, which then takes more or less the form of a disc, in which the similarly affected coils may be connected together, so that a single pair of brushes still serves to take off the current. In some cases the coils are connected to commutators of special design, which have the effect that

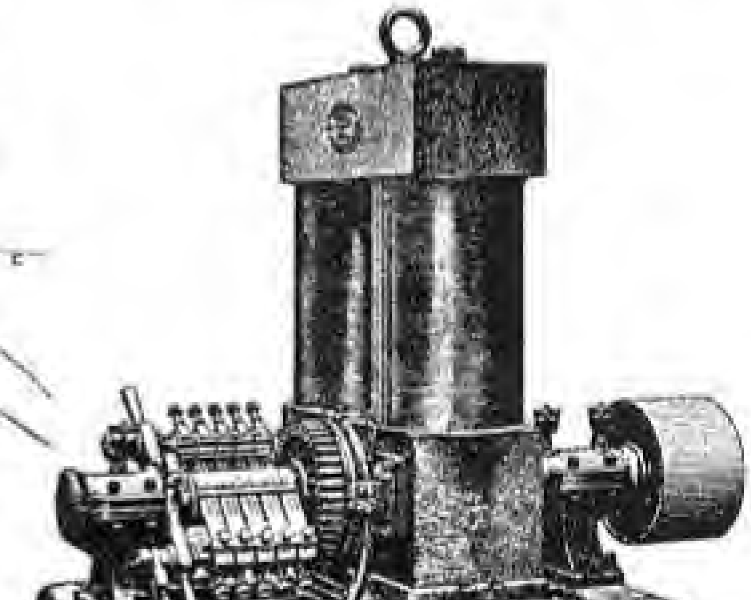


Fig. 12.

each coil is entirely cut out of circuit for a time, during that part of its movement in which there is little or no electromotive force induced in it. The Brush dynamo, which took a prominent place in the early industrial development of electric lighting, and the Thomson-Houston dynamo, are instances in point.

In *alternate current dynamos* the armature consists usually of a group of coils, joined in parallel or series, attached to a disc which revolves in the space between a corresponding group of pairs of magnet-poles, so that rapidly alternating transient currents are induced as the coils pass the successive poles, and these currents pass to the external circuit through a simple collector which is not a commutator. In some cases the armature is stationary, and the field-magnets revolve. The field is usually excited by an auxiliary dynamo of the continuous current type. It is impossible in the space at our disposal to describe the great variety of forms which alternate current machines have taken in the hands of Siemens, Gordon, Ferranti, Westinghouse, Mordey, and others. Dynamos of this class are now acquiring a special importance from their use in connection with transformers in Electric Lighting (q.v.), and are being made for this purpose of very great size and power. In alternate current dynamos, the relation between the strength of the current and electromotive force induced in the moving coils depends not merely on the resistance of the circuit, but also on its coefficient of self-induction, which has the effect of making the maximum of strength in each transient current lag behind the maximum of electromotive force. It has been shown experimentally and theoretically, by Adams and Hopkinson, that in consequence of self-induction two similar alternate current machines driven independently, but started at the same speed, and connected in parallel, will control one another, so that the phases of the currents will continue to agree.

Dynamos, of whatever type, may be regarded as machines for converting energy from a mechanical into an electrical form, and from this point of view a matter of prime importance is what is called the efficiency of the machine, which is the ratio of the electrical power the dynamo gives off, available for use outside the machine, to the power used to drive the machine. The electrical energy given off falls short of the mechanical energy absorbed, in consequence of (1) mechanical friction; (2) the generation of eddy currents, to be prevented as much as possible by laminating the iron core of the armature; (3) magnetic friction or 'hysteresis,' by which every reversal of magnetism in the iron causes dissipation of energy, apart from the production of eddy currents; (4) the energy consumed in maintaining the magnetic field; and (5) the heating of the armature in consequence of the resistance of its own coils. The aggregate effect of these sources of loss is that in a good machine about 90 per cent. of the driving power is available as electric energy in the external circuit. Dr Hopkinson has shown by careful measurements that machines of the type illustrated in fig. 12 may attain an efficiency of over 93 per cent.

The Dynamo as a Motor.—Just as a conductor when made to move across the lines of magnetic force has a current generated in it, so when a current is made to pass along a conductor placed in a magnetic field, the conductor tends to move across the field in the direction which would reduce the current by inducing an opposing electromotive force. Even before Faraday's discovery of the induction of current in a conductor by its movement in a magnetic field, he had shown (in 1821) that the reverse process was possible, and soon afterwards various forms of magneto-electric engines were devised by Barlow and Sturgeon, and later by Ritchie, Henry, Dal Negro, Joule, and others, which employed electric currents to do mechanical work on a small scale. In 1838 Jacobi constructed an electric motor of sufficient power to propel a small boat, using a group of electro-magnets, which revolved on a disc between opposite groups of other electro-magnets, which were fixed. Some time before the application of the ring-armature to dynamos by Gramme, it had been used in a motor by Pacinotti, and the principle had been explicitly stated that any electric motor might be used to produce currents, but it was not until Gramme's time that the full significance of this principle was generally recognised. The action of the dynamo is in fact reversible; the same machine which converts mechanical into electrical energy will serve the opposite function equally well. Power may therefore be conveyed to any distance by using a dynamo to produce currents, conducting these to the distant spot, and utilising them there to produce mechanical effect by means of another dynamo acting as a motor. The second dynamo may be a counterpart of the first; in some cases, however, it may be desirable, for the sake of lightness or for other special reasons, to adopt a different construction in the motor. In general, however, the most efficient generator is also the most efficient motor. The experiments of Hopkinson, in a case where some 50 horse-power was being transmitted in this way, show that the double conversion of energy from the mechanical to the electrical, and back again to the mechanical form, may be accomplished with a total loss of no more than 13 per cent.; the efficiency of the motor and that of the generator being each above 93 per cent.

Alternate current dynamos form fairly efficient motors when driven by alternate currents; they require, however, to be started in synchronism with the impulses received from the generating machine, but once started they tend to remain in synchronism. Special forms of motor for alternate currents have been designed by several inventors, but these have scarcely as yet passed the experimental stage.

Ear. The apparatus of hearing, as it exists in man and the mammalia, is composed of three parts—the external ear, the middle ear or tympanum, and the internal ear or labyrinth.

The *external ear* consists of two portions, the *auricle* or *pinna* (the part popularly recognised as the ear), and the *auditory canal* or *external meatus*.

In man, the auricle, on its outer or more exposed surface, presents various eminences and depressions, resulting from the form of its cartilaginous framework. These have received special anatomical names, to which it is unnecessary to advert further than to mention that the deep capacious central space to which several grooves converge is termed the *concha*, and that the lowest and pendulous portion of the ear is termed the *lobe*. The cartilage forming the basis of the external ear consists of one principal piece, in which there are several fissures, which are filled up by fibrous membrane. Several muscles are described as passing from one part of the auricle to another, but they are so little developed in man that they do not require notice; there are additionally three muscles—the *attollens aurem* (or *superior auris*), the *attrahens aurem* (or *anterior auris*), and the *retrahens aurem* (or *posterior auris*), which pass from adjacent parts of the scalp to the ear, and which, though more developed than the previous group, are of little or no real importance in man (at least in his civilised state), but are of considerable use in many mammals. Their actions are sufficiently indicated by their names.

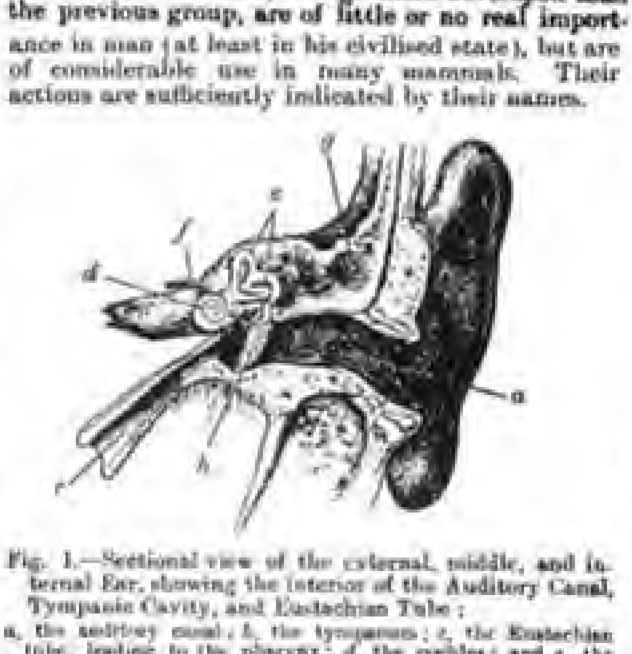


Fig. 1.—Sectional view of the external, middle, and internal Ear, showing the interior of the Auditory Canal, Tympanic Cavity, and Eustachian Tube:
a, the auditory canal; *b*, the tympanum; *c*, the Eustachian tube, leading to the pharynx; *d*, the cochlea; and *e*, the semicircular canals and vestibule, seen on their exterior by the removal of the surrounding bony tissue; *f*, auditory nerve; *g*, temporal bone.

The auditory canal passes from the concha inwards, and a little forwards, for rather more than an inch. It is narrower at the middle than at either extremity; and on this account there is often considerable difficulty in extracting foreign bodies that have been inserted into it. The membrane of the tympanum which terminates it is placed obliquely, in consequence of the lower surface of the meatus being longer than the upper. The canal is partly cartilaginous and partly osseous; the osseous portion consisting in the fœtus of a ring of bone, across which the membrane is stretched, and in many animals remaining persistently as a separate bone. The orifice of the meatus is concealed by a pointed process, which projects from the facial direction over it like a valve, and which is called the *tragus*, probably from being sometimes covered with bristly hair like that of a goat (*tragos*); and it is further defended by an abundance of ceruminous glands, which furnish an adhesive, yellow, and bitter secretion, the cerumen or wax, which entangles small insects, particles of dust, and other small foreign bodies, and prevents their further passage into the meatus.

The *middle ear*, or *cavity of the tympanum*, is a space filled with air which is received from the Pharynx (q.v.) through the Eustachian tube (see fig. 1, *b*, *c*), and traversed by a chain of very small movable bones (fig. 2), which connect the membrane of the tympanum with the internal ear. It lies, as its name implies, between the external meatus and the labyrinth or internal ear, and opens posteriorly into the cells contained in the mastoid portion of the temporal bone, and anteriorly into the Eustachian tube. The cavity is of an irregular shape, and is lined by a very delicate ciliated epithelium, which is a prolongation of that of the pharynx through the Eustachian tube.

Its external wall is in great part formed by the membrane of the tympanum, which is nearly oval, and placed in a direction slanting inwards, so as to form an angle of about 45 degrees with the floor of the auditory canal (see fig. 1). The handle of the malleus (or hammer), the first of the chain of ossicles (see fig. 2), is firmly attached to the inner side of this membrane in a vertical direction as far downwards as the centre, and by drawing it inwards, renders its external surface concave.

Its internal wall has two openings communicating with the internal ear, each of which is closed by a delicate membrane. These openings are termed, from their respective shapes, the *fenestra ovalis*, and the *fenestra rotunda*; the former leads to the vestibule, and is connected by its membrane with the base of the stapes (or stirrup-bone), the last of the chain of ossicles; while the latter opens into the cochlea.

The ossicles of the tympanum are three—viz. the *malleus*, the *incus* (or anvil), and the *stapes*. We have already explained how the malleus is connected with the membrane of the tympanum by means of its handle. Through this connection, the tension of that membrane may be modified by the agency of a muscle which is attached to this ossicle. This muscle is the *tensor tympani*, which arises from the under surface of the petrous portion of the temporal bone, and is inserted into the handle of the malleus immediately below the commencement of the *processus gracilis*. The mode in which the malleus articulates with the incus is sufficiently explained by the figure. The *incus* much more closely resembles a molar tooth with two fangs than the anvil from which it derives its name. Of the two processes which it gives off (see fig. 2), the short one, *sc*, runs backwards, and is attached to the posterior wall of the tympanum near the entrance to the mastoid cells; while the long one, *lc*, inclines downwards, and terminates in the lenticular or orbicular process, *a*, to which the head of the stapes is attached. The *stapes* is almost sufficiently described by the figure. It has a head, neck, two branches, and a base, which, as has been already mentioned, fits into the *fenestra ovalis*. A minute muscle, the *stapedius*, takes its origin from a hollow conical eminence termed the *pyramid*, which lies behind the *fenestra ovalis*, and is inserted into the neck of the stapes; its function is probably to act as an antagonist to the *tensor tympani*.

Fig. 2.—Ossicles of the left Ear, as seen from the outside and below:
m, head of the malleus; *g*, the slender process, or processus gracilis; *h*, the manubrium or handle; *sc*, the short crus, and *lc*, the long crus of the incus; *a*, the position of the lenticular process, through the medium of which it articulates with the head of the stapes; *s*, the base of the stapes. Magnified three diameters.

The Eustachian tube, into which the tympanic cavity opens anteriorly, is about an inch and a half in length, and passes downwards, forwards, and inwards to its opening in the pharynx. It is partly osseous, but chiefly cartilaginous. Its chief use is to allow the free passage of air in and out of the tympanum.

The *internal ear* or *labyrinth* is the essential part of the organ of hearing, being the portion to which the ultimate filaments of the auditory nerve (see BRAIN, NERVOUS SYSTEM) are distributed. It is composed of three parts—viz. the *vestibule*, the *semicircular canals*, and the *cochlea*, which form a series of cavities presenting a very complicated arrangement, and lying imbedded in the hardest part of the petrous portion of the temporal bone. They communicate externally with the tympanum by the two openings already described—the *fenestra ovalis*, and the *fenestra rotunda;* and internally with the internal auditory canal, which conveys the auditory nerve from the cranial cavity to the internal ear. The very dense bone immediately bounding these cavities is termed the *osseous labyrinth*, to distinguish it from the *membranous labyrinth*, which lies within a portion of it.

The *vestibule* is a common central cavity into which the semicircular canals and the cochlea open (see fig. 3, V). It is about a fifth of an inch in height and in length from before backwards, its transverse diameter (from side to side) being somewhat less. On its posterior wall are five orifices

Fig. 3.—Interior of the Osseous Labyrinth:

V, vestibule; *aq*, aqueduct of the vestibule; *r*, macula cribrosa; S, semicircular canals; *s*, superior; *p*, posterior; *i*, inferior; *a*, *a*, *a*, the ampullar extremity of each; C, the cochlea; *sv*, osseous zone of the lamina spiralis, above which is the scala vestibuli, communicating with the vestibule; *st*, scala tympani, below the spiral lamina. Magnified 3½ diameters.

for the semicircular canals, one of the orifices being common to two of the canals. Anteriorly, the cochlea enters it by a single opening, partially divided by an osseous partition—the *lamina spiralis ossea*. On its outer wall is the *fenestra ovalis*, and on its inner are the *maculæ cribrosæ*, containing several minute orifices for the entrance of filaments of the auditory nerve.

The *semicircular canals* are three in number, and open into the vestibule by means of five orifices, the two vertical canals having at their non-ampullate extremities a common orifice. They vary in length, and notwithstanding their name, each is considerably more than a semicircle, the superior vertical canal being the longest. The average diameter is about a twentieth of an inch, one extremity of each canal exhibiting a dilatation or *ampulla*. Each canal lies in a different plane, very nearly at right angles to the planes of the other two, hence their names of the *superior vertical*, the *inferior vertical*, and the *horizontal* canals.

The *cochlea*, which derives its name from its resemblance to a common snail-shell, forms the anterior portion of the labyrinth. It consists of an osseous and gradually tapering canal, about an inch and a half in length, which makes two turns and a half spirally around a central axis, termed the *modiolus*, which is perforated at its base for the entrance of the filaments of the cochlear portion of the auditory nerve. This spiral canal gradually diminishes towards the apex of the cochlea. At its base it presents an opening into the vestibule, partially divided into two. In the recent state, one of these openings (*scala tympani*) does not communicate with the vestibule, but is closed by the membrane of the *fenestra rotunda*. Its interior is subdivided into two passages (*scalæ*) by an osseous lamina. This is the *lamina spiralis*, which incompletely divides the cochlea into an upper passage, the *scala vestibuli*, and a lower one, the *scala tympani*—i.e. the division is incomplete so far as the skeleton goes, but is completed during life by soft parts afterwards to be described. At the apex these two passages communicate by an opening to which the term *helicotrema* has been applied.

We now return to the *membranous labyrinth*. The membranous and osseous labyrinths have the same shape, but

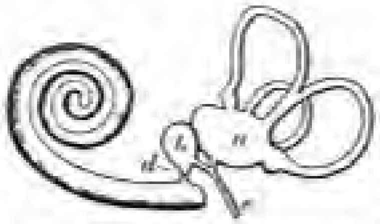


Fig. 4.—Scheme of Mammalian Labyrinth:

a, utricle; *b*, saccule; *c*, aquæductus vestibuli, dividing into two branches, going to saccule and utricle respectively; *d*, canalis or ductus cochlearis.

the former is considerably smaller than the latter, a fluid, termed the *perilymph*, intervening in some quantity between them. At certain points recent investigations have shown that the membranous is firmly adherent to the inner surface of the osseous labyrinth. The vestibular portion consists of two sacs, an upper and larger one, of an oval shape, termed the *utriculus*, and a lower and smaller one, of a globular shape, called the *sacculus*. The membranous semicircular canals resemble in form and arrangement the osseous canals which inclose them, but are only one-third of the diameter of the latter.

It will be remembered that the osseous structure of the cochlea is that of a tube almost but not quite divided into two by the lamina spiralis ossea. The division is completed by the lamina

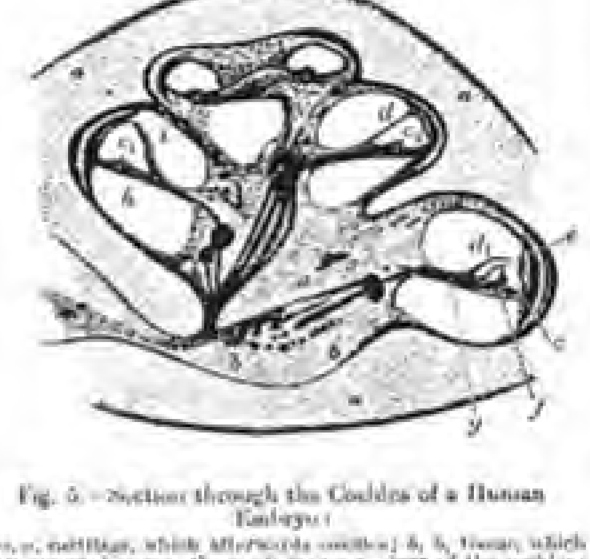


Fig. 5.—Section through the Cochlea of a Human Embryo:

a, *a*, *a*, cartilage, which afterwards ossifies; *b*, *b*, tissue, which afterwards becomes the modiolus; *c*, c_1, duct of the cochlea; *d*, d_1, membrane of Reissner; *e*, membrana tectatoria, rather elevated from its proper position; *f*, position afterwards occupied by organ of Corti; *g*, lamina spiralis; *h*, scala tympani; *i*, scala vestibuli.

spiralis membranacea (or basilar membrane). From near the junction of the osseous with the membranous lamina springs the membrane of Reissner, which, stretching across to the wall of the osseous cochlea, shuts off a third space known as the *ductus cochleæ*. The cochlear duct terminates blindly at both ends, but near its lower extremity is connected with the saccule through a delicate membranous channel known as the *ductus reuniens*. Upon the basilar membrane is situated the organ of Corti, which consists of the following parts (to name only those of most importance) from within outwards: (1) a single row of so-called inner hair-cells; (2) the two rods of Corti (known as inner and outer); (3) four or five rows of outer hair-cells. These are again protected by the curtain-like *membrana tectatoria*.

The auditory nerve leaves the medulla oblongata together with the facial, and passing into the internal auditory meatus, divides into two branches, which pass respectively to the vestibule and the cochlea. The former ends in a peculiarly modified epithelium with projecting processes situated in the ampullæ of the semicircular canals and on certain spots within the saccule and utricle, known as the *maculæ acusticæ*. In the latter situation are also found small crystalline bodies, called

Fig. 6.

a, lamina spiralis ossea, with nerve bundles from cochlear nerve; *b*, *b*, lamina spiralis membranacea; *c*, inner rod or pillar of Corti; c_1, outer rod or pillar of Corti; *d*, inner hair-cell; *e*, outer hair-cells; *f*, nerve fibres; *g*, membrana tectatoria.

otoliths, which are suspended around the maculæ: by exactly what means this suspension is effected is at present unknown. The cochlear branch of the auditory nerve probably terminates in the inner and outer hair-cells of the organ of Corti (see fig. 6). The saccule and utricle communicate with each other and with the interior of the skull through the *aquæductus vestibuli*, while the *aquæductus cochleæ* connects the perilymph of the scala tympani with the arachnoid space.

PHYSIOLOGY.—(1) *Of the External Ear.*—A true auricle only exists in the mammalia, and in this class it varies from little more than an irregularly shaped cartilaginous disc with little or no motion, as in man and the quadrumana, to an elongated funnel-shaped ear-trumpet movable in all directions by numerous large muscles, as in the horse, the ass, and the bat. The mode in which we see it employed by those animals in which it is highly developed sufficiently indicates that its main function is to collect and concentrate the sounds which fall upon it. But the experimental investigations of Savart, with an apparatus constructed to resemble the tympanic membrane and the external auditory apparatus, show that these parts are also adapted to enter into vibrations in unison with those of the air; and he suggested that the human auricle, by the various directions of different parts of its surface, could always present to the air a certain number of parts whose direction is at right angles with that of the molecular movement of the air, and therefore in the most favourable position for having the vibrations communicated.

(2) *Of the Tympanum and its Contents.*—Savart's experiments show that the membrane of the tympanum is thrown into vibration by the air, and that it always executes vibrations equal in number to those of the sonorous body which excites the oscillations in the air. He further ascertained that the malleus participates in the oscillations of the tympanic membrane, and that these vibrations are propagated to the incus and stapes, and thus to the membrane of the *fenestra ovalis*. The malleus has further the office of regulating, through the *tensor tympani* muscle, the tension of the tympanic membrane; and to allow of the motion necessary for this purpose, we find movable joints between it and the incus, and again between the latter bone and the stapes. The contraction of the stapedius muscle similarly modifies the tension of the membrane of the *fenestra ovalis;* and as compression or the reverse exercised on this membrane extends to the perilymph, and is propagated through it to the *fenestra rotunda*, the tension of the membrane of the latter opening is also influenced by the muscle in question. The incus is much more limited in its motions than either of the other bones, and its use seems to be to complete the chain of ossicles in such a manner as to prevent any sudden or violent tension of the membranes, such as we can easily conceive might occur if the conductor between the membranes were a single bone. The presence of air in the tympanic cavity serves a double purpose: in the first place, it preserves a uniform temperature on the outer surfaces of the fenestral membranes, and thus supports a fixed elasticity in them, which would not be the case if they were freely exposed to ordinary atmospheric changes; and secondly, the action of the chain of ossicles as conductors of sound is materially increased by their being completely surrounded by air, as is obvious from the first principles of acoustics; further, were it not for the presence of air within the tympanum, the drum membrane would be arched inwards, and the resulting displacement and change of tension would produce deafness.

(3) *Of the Labyrinth.*—Sonorous vibrations may be conducted to the labyrinth through the bones of the skull; but during the ordinary act of hearing, the movements of the tympanic membrane are propagated through the chain of ossicles and the labyrinth, and thus perceived by the auditory nerve. A considerable amount of mystery surrounds the functions of the saccule and utricle; indeed, on this subject so little is at present accurately known that no good purpose would be served by discussing it further. The view, until recently accepted, that these parts were concerned in the perception of sounds as distinguished from

tones (i.e. notes), has been rendered doubtful by recent researches.

The semicircular canals have been of late years made objects of study by many physiologists. It has now been conclusively demonstrated that they are intimately associated with the maintenance of the body in the erect position. Injury of a semicircular canal tends to produce rotatory movements of the body and eyes, and it has therefore been suggested that the functions of these organs may be connected with the reflex act of listening, as exemplified in the lower animals by pricking the ears and rotation of the head. From experiments on animals, and observations on the human subject in disease, it has now been proved that a lesion of the semicircular canals is followed by giddiness or vertigo, which manifests itself either in involuntary falling, rotation, or in a subjective condition, during the continuance of which surrounding objects seem to revolve round the patient. It is generally believed by physiologists that the cochlea has the special function of analysing sounds. It has been found that the basilar membrane is not equally broad throughout, but that it increases gradually from base to apex. It therefore presents a series of strings of different lengths, and the short ones are assumed to vibrate in the perception of high notes, while the long ones are stimulated to motion by low tones. The lower part of the cochlea is therefore chiefly concerned in the perception of sounds of high pitch, while the upper parts respond to those of low pitch. Some observers, however, do not accept this view—e.g. Voltolini and Rutherford, but believe that sounds are analysed in the auditory centre, which, according to the investigations of Munk and Ferrier, is located in the temporal lobe. For the hearing of birds, reptiles, &c., see BIRD, REPTILES, &c.

THE DISEASES OF THE EAR.—It is manifestly impossible to attempt any account of the various individual ear diseases in an article like the present. Since aural surgery has become an exact science, the medical profession have come to realise that such phrases as a 'cure for deafness,' or a 'treatment for earache,' are not only inexact but absurd. Deafness—varying in degree from a slight impairment of hearing up to total inability to perceive sounds—may be due to a great variety of causes, and any of these causes may produce not only deafness, but noises in the head. Thus the auditory canal may be blocked by wax, the products of skin eruptions affecting its lining membrane, tumours, masses of fungus, the results of inflammation, &c. The tympanic membrane may be displaced or thickened, the ossicles may be impeded in their movements by the presence of exudation, or by fibrous adhesions or swelling of the mucous membrane within the tympanum. Then again these parts may be injured either by disease or by violence. The auditory nerve may be affected in any part of its course from the auditory centre to the labyrinth, and thus deafness may result.

We have only indicated some of the pathological causes of impaired hearing, but enough has been said to show that before deafness can be prescribed for with any hope of success, an examination of the ear must be made by a competent medical man.

Turning now to earache, let us consider some of its causes. Sometimes it is due to the presence of boils in the auditory canal, or the whole lining membrane of the passage, including the outer layer of the membrana tympani, may become inflamed. Perhaps the most common cause of earache is inflammation of the drum-cavity. Such inflammation often stops before the inflammatory products have taken on a purulent character. This mild form is very common in children, and often sows the seeds of deafness in after-life if appropriate treatment be not applied. Occasionally earache is altogether due to the presence of a diseased tooth, which need not necessarily be tender or painful. By far the most dangerous form, however, is that which arises in connection with a so-called 'running ear.' The general meaning of this symptom in such cases is an accumulation of decomposing matter and sometimes diseased bone in close proximity to the brain, and a fatal result is by no means uncommon. Vertigo, or giddiness, is a very frequent symptom of ear disease, and can often be relieved or cured by attention to this organ.

A feeling of fullness in the head, and disinclination for mental effort, is far from uncommon. Rarer or less important symptoms of aural affections are (1) anomalies of taste, owing to involvement of the chorda tympani nerve on its way through the drum-cavity; (2) paroxysmal cough and sneezing; (3) neuralgia of the head; and (4) epilepsy; the last named being fortunately extremely uncommon. We should not be justified in omitting to mention that nasal diseases, especially in children, are often the causes of deafness. This is all the more important, because such cases when taken early can almost always be cured.

From what has been said, it will be obvious that any remarks we could, without unduly extending this article, make with regard to treatment would be useless. We feel it, however, to be our duty to warn those who suffer from ear disease from consulting unqualified quacks. This resort to empirics is all the more uncalled for as there are now numbers of respectable highly-qualified practitioners who devote attention to aural maladies.

There are, however, a few points of general interest and of great importance which may be touched upon.

It is a common delusion that it is a dangerous thing to cure a discharge from the ear. Now this is by no means true; indeed it may be at once stated that life is never safe so long as a chronic putrid discharge issues from the ear. In all such cases it is not only safe but necessary to syringe the meatus with a warm disinfecting solution, such as boracic lotion, or water to which some Condy's fluid has been added. The ear should then be dried by carefully introducing a wick of absorbent cotton wool. The origin of the superstition anent the danger of stopping a discharge is easily explained. If the putrid matter be present, it is better that it should find its way out. Now, if in such a case some physical obstacle prevents its exit, a fatal result is apt to supervene. It had thus been noticed that in many cases the 'running from the ear' stopped before dangerous symptoms set in, and hence the delusion. Another point as to which much misapprehension exists, is the danger caused by the presence of a foreign body in the ear. It has been observed by a noted specialist that 'the point of a dagger in the meatus is less likely to do harm than unskilled efforts to remove it.' No endeavour should ever be made to remove a foreign body which is not seen, and all probing in the dark is to be absolutely avoided. Most extraneous objects can be removed simply by means of warm water and a syringe used by a skilled hand. If the object be a pea, bean, or any other body which is likely to swell from absorbing moisture, it is better not even to attempt syringing, and to wait until skilled advice can be obtained.

Should an insect get into the ear, it can almost invariably be syringed out with warm water, or if a syringe be not at hand, the ear may be filled with warm oil or even water.

Deafness occasionally runs in families, and the symptom is then usually due to chronic thickening of the tympanic structures. Persons in whom this hereditary tendency exists should, on the first indication of ear trouble, seek advice.

It need hardly be said that picking the ears ought to be avoided. This habit may lead to the 'ear pick' being driven through the drum membrane. Should the ear be made to bleed, and should there be any doubt as to whether the drum membrane be wounded, scrupulous care should be taken to prevent the entrance of fluid. If the tympanic membrane be accidentally perforated, syringing, or instilling ear drops is almost certain to be followed by inflammation. After fifty the hearing tends to fall off a little, but except possibly in extreme old age, marked deafness for conversation is always abnormal. It is a curious fact that elderly people who require a watch to be put quite close to the ear, can often hear conversation well. This is explained by the fact that after middle life the auditory nerve is less sensitive, and the power of readily perceiving high-pitched tones is then less acute.

According to the writer's experience, almost complete deafness in one ear, while the other is perfect, does not necessarily endanger the sound organ. Others, however, take the opposite view. It must be remembered that in most cases, impairment of hearing is bilateral, and this is always the case when deaf persons have to be addressed in an elevated voice.

The instruction and training of children who have been born deaf is dealt with in the article DEAF AND DUMB.

EAR-TRUMPETS, &c.—The number of ear-trumpets now advertised makes any detailed account of them impossible. The application of one of three principles exists in most, if not all, to wit: (1) a tube with a suitable ear-piece at one extremity, and a more or less conical mouthpiece at the other; (2) a bell-shaped sound-collector, with an ear-piece for insertion into the auditory canal; (3) appliances for tilting the auricle forwards. There can be no doubt that a person who desires to purchase an ear-trumpet will best gain his end by carefully testing a large number of instruments, and choosing that which suits him best.

As a rule small invisible instruments are useless. Politzer has constructed a small tube made of vulcanite and flesh-tinted, the object of which is to prolong the tragus backwards; in a very few cases this is found to be an exception to the above rule. The same authority has attempted, by a special appliance, to conduct the vibrations of the auricle directly to the tympanic membrane. The Audiphone (q.v.) and dentiphone are only useful in a few cases; in both the object is to convey sonorous vibrations through the teeth and the auditory nerve. The so-called fonifero is a rod for connecting the larynx of the speaker with the teeth of the auditor. In some cases—those in which the drum membrane is destroyed—the introduction of an artificial drum is useful. This fact has been taken advantage of by unscrupulous quacks, who sell for several pounds an appliance not differing in its essentials from 'Toynbee's artificial tympanum,' which can be had for a shilling or two.

Earths, the name applied by the alchemists and earlier chemists to certain substances now known to be oxides of metals, which were distinguished by being infusible, and by insolubility in water. The term was made to include the oxides of calcium, strontium, and barium, which undergo chemical change by contact with water, and yield alkaline solutions. On account of this property those oxides were called the alkaline earths. The term earth is now disappearing from modern text-books of chemistry. See SOILS.

Eau de Cologne, a celebrated perfume, the reputed inventor of which is Johann Maria Farina (1685–1766), a native of Piedmont, who settled in Cologne in 1709, though his claim to be the inventor is not undisputed. The secret of the process of its manufacture is claimed by from thirty to forty firms, bearing the name of Farina, now existing in Cologne. The recipe is said to be twelve drops of each of the essential oils neroli, citron, bergamot, orange, and rosemary, along with one drachm of Malabar cardamoms and one gallon of rectified spirit. The whole is distilled together, and the condensed liquid constitutes Eau de Cologne. In Great Britain, where chemists and others make an article little, if at all, inferior to the imported one, the oils are usually mixed with a highly purified spirit, and the subsequent distillation dispensed with.

Effervescence. Nearly all gases are more or less soluble in water, the amount of solubility depending on various conditions of pressure and temperature. As a rule, the lower the temperature and the greater the pressure, the greater is the solubility of a gas, so that when the temperature of such a solution is raised, or the pressure lowered, the gas escapes in small bubbles, giving rise to the phenomenon of effervescence. The most familiar instance of effervescence is when a bottle of soda-water is uncorked, the excess of carbonic acid gas over what can remain in solution escaping with effervescence. Again, when a seidlitz powder is mixed with water, effervescence occurs, owing to the inability of the water to retain the gas in solution. Many slight circumstances affect effervescence. Most people know that by stirring a glass of soda-water, or by dropping into it a fragment of cork or a crumb of bread, greater effervescence occurs. Sometimes the liquid is rather viscid, and a persistent froth is produced, as when a siphon of lemonade is discharged into a tumbler. In such a case, the addition of a few drops of milk or of a little alcohol causes more rapid effervescence and settling of the froth. In the former of these cases, the bread crumb or the stirring acts by making it more easy for the gas to form bubbles and escape. In the latter case, the effect of milk may have a twofold cause, one similar to that of the crumb, the milk globules acting as nuclei; the other similar to the calming influence of oil on sea foam,

the natural oil, butter, here coming into play. The alcohol merely acts by thinning the liquid.

Efflorescence, in Chemistry, is the term applied to the appearance of a white incrustation on the surface of certain bodies, as when a salt loses its water of crystallisation, and presents a white powdery appearance on the surface. Common washing-soda exposed to the air affords a good illustration of this phenomenon.

Electricity.* If a stick of sealing-wax is rubbed vigorously with woollen cloth it will be found capable of attracting small shreds of paper. This is the simplest experiment in electricity. Many other substances, such as resin, vulcanite, glass, &c., can be made to show the same phenomenon. To obtain the best effect with any given substance, a particular rubber must be chosen. For example, a cat's fur, slightly warmed, is very efficient in electrifying vulcanite or resin; while silk, amongst simple substances, should be used to excite glass. It is now known, however, that any two different substances, which can be rubbed together, become electrified by the friction. Thus, if wax and glass are rubbed together, they will both become electrified—i.e. capable of attracting light objects. And so, in the other instances, it can be shown by experiment that the cloth is electrified as well as the wax, the cat's fur as well as the vulcanite, the silk as well as the glass. Moreover, the two substances so electrified by mutual rubbing are found to attract one another, being indeed *oppositely* electrified—a term which the following experiment will elucidate.

Let two pieces of glass be electrified by rubbing each with a distinct piece of resin. The pieces of resin will also be electrified, and it will be found (1) that the pieces of glass repel each other; (2) that the pieces of resin repel each other; (3) that each piece of glass attracts each piece of resin. Exactly the same phenomena of attraction and repulsion will be shown—only much more powerfully because of the greater efficiency of the rubbing—if the pieces of resin are rubbed with cat's fur and the pieces of glass with silk.

Again, let a small light body, a pith-ball for example, be suspended at the end of a silk thread. This will be attracted by either the resin or the glass. But if it is allowed to come into contact with, say, the resin, it will immediately be repelled by the resin and strongly attracted by the glass. And if it should be allowed to touch the glass, it will at once be repelled by the glass and strongly attracted by the resin. By such contact the pith-ball itself becomes electrified; for it will repel a second pith-ball similarly treated. We are thus led to the following conclusions. Repulsion exists between bodies which are similarly electrified, and attraction between bodies which are oppositely electrified. Bodies, electrified by mutual rubbing, become oppositely electrified. A body, electrified by contact with an electrified body, becomes electrified similarly to that body. Substances which like silk-rubbed glass repel silk-rubbed glass and attract wool-rubbed resin are vitreously or *positively* electrified, while bodies which attract silk-rubbed glass and repel wool-rubbed resin are resinously or *negatively* electrified. The indication of the two kinds of electrification by opposite signs is very appropriate, but the application of the positive sign to one rather than to the other is a matter of convention and purely arbitrary.

To study electrical phenomena by means of metallic substances, it is necessary first of all to *insulate* them—i.e. to support them on glass, vulcanite, paraffin, &c., or to hang them by silk threads. The significance of the term insulation will appear from the following experiment. Hang two metal balls, one by a silk thread and the other by a wire, and touch them with a piece of wax strongly electrified by friction. On trial, the silk-suspended ball will be found electrified; but not so the wire-suspended ball. Or, again, set a metal ball on a glass support, but let a wire connect it with the table or the hand. It will be found impossible to electrify it by contact with an electrified body. But remove the connecting wire, and immediately a single contact will suffice to electrify the ball. Thus we recognise two kinds of substances—viz. *insulators* and *non-insulators*. The latter are usually called *conductors*, and include all ordinary metals. Such conductors can be electrified only when they are insulated.

When a body is sufficiently strongly electrified and brought very near another body originally unelectrified, a spark will pass between them even before they are made to touch. If this second body is the finger or knuckle, the spark will be accompanied by a peculiar sensation called an electric shock. Now let us take such a highly electrified conductor A, and bring pretty near to it a second insulated conductor B, but not so near as to cause a spark to pass. If, then, the finger be brought near enough to B a shock will be felt, a spark will pass between B and the finger, although B was originally not electrified. Thus B has become electrified by being brought into the neighbourhood of A. This mode of electrification is called electrification by *induction*. As Faraday clearly pointed out, it 'has the character of a first, essential, and fundamental principle,' and its thorough comprehension is of prime importance.

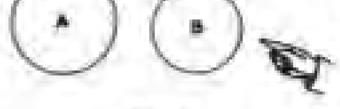


Fig. 1.

As it is our purpose to regard the whole subject from the Faraday point of view, it will be convenient to define certain useful terms. The *electric field* is any region of air, glass, vulcanite, or other non-conducting substance surrounding or containing electrified bodies. In it and through it the electric forces act; hence it is convenient to call such insulating substances *dielectrics*, especially when attention is being drawn to the rôle they play as transmitters of electric action. To investigate the properties of an electric field it is generally necessary to bring into it a conductor, as in the experiment just described. In that experiment the induced electrical condition of B was studied by means of a physiological sensation, partly optical, partly muscular. A far better way, however, of studying the phenomena of induction is to make use of the fundamental laws of attraction and repulsion between electrified bodies, as they are mechanically applied in such instruments as the gold-leaf electroscope, Coulomb's torsion balance, Thomson's quadrant electrometer, &c.

In the gold-leaf electroscope (invented by Bennet in 1787), two light strips of gold-leaf hang from the lower end of a metal rod, which passes vertically through an opening in the top of a glass bottle and expands above into a plate. If a piece of rubbed sealing-wax or other electrified body be brought near the plate, the gold leaves will repel each other and diverge. In other words, the conductor, consisting of the plate, rod, and gold leaves, has been introduced into an electric field, and has in consequence become electrified by induction. This is shown by the repulsion between the similarly electrified gold leaves. The nearer the electrified body is brought, the stronger is the electric field surrounding the electroscope, the wider do the gold leaves diverge. Here evidently the repulsion tends to lift the centre of gravity of each gold leaf, and is finally balanced by the action of gravity. A cylinder of wire gauze, placed just inside the glass case, improves the action of the instrument. The other two instruments mentioned above depend for their action upon the same general principle—viz. the equilibrium of a body under the action of the electrical and what, for distinction, might be called the material forces.

Fig. 2.

Coulomb's torsion balance is historically the first true electrometer—i.e. the first instrument whose indications were capable of quantitative interpretation. In it the force with which one small charged sphere is repelled by another similarly charged is balanced by the torsion of a wire, which acts as suspension to a horizontal insulating rod bearing the one sphere at one of its ends. By rotation of the upper end of the wire this sphere can be made to move in a horizontal circle; and at some point in the circumference of the circle the other sphere is fixed. If the spheres are charged, **the rod bearing the movable sphere will take up a position of equilibrium under the combined action of the electrical force and the torsion of the suspension; and these, as regards their rotatory effect upon the rod, must be equal. But by the laws of elasticity, the force of torsion is proportional to the twist of the wire, and the twist itself is as easily measured as the distance between the spheres.**

Hence to the degree of accuracy to which the geometrical configuration of the system is known, the electric force can be calculated in terms of the elastic constants of the wire. In this way Coulomb proved, in 1785, that two small charged balls repelled each other with a force which diminished as the square of the distance increased.

Sir William Thomson's quadrant electrometer is, in a certain sense, a development of Coulomb's torsion balance. Its many nice electrical and mechanical devices render it a peculiarly delicate and accurate instrument for measuring minute differences in electrification. Essentially it consists of four hollow brass quadrants, which when fitted close together form a squat hollow cylinder bounded above and below by parallel plane faces. For electrical purposes they must, however, be drawn a little apart, so that when looked at from above or from below they have the appearance as shown in the figure—viz. that of a circular disc with two mutually perpendicular diametral clefts. Each quadrant is insulated on its own glass support; but each is joined to its opposite by a wire, so that electrically they go in pairs. From one of each pair a vertical rod leads to the outside of the case in which the whole is inclosed. These rods are called the *electrodes*, and their function is to bring the pairs of quadrants into electrical connection with external bodies. The inside corner of the top and bottom of each quadrant is cut away, so that at the centre a small circular space is left concentric with the external cylindrical surface of the quadrants. In the hollow space inclosed by the quadrants a light charged body (E in fig. 3, *a* in fig. 4) of a convenient shape hangs, its axis of suspension passing up through the circular central space just mentioned. The light body can rotate about this vertical axis only, and its motion is controlled by the torsion of the suspension. If the four quadrants are all connected together, the suspension makes the light body hang so as to lie with its longer axis of symmetry parallel to one of the diametral clefts separating the quadrants. If, however, the pairs of quadrants are disconnected, and by connection with external bodies brought into different electric conditions, electrical forces will at once act upon the charged body and rotate it until they are balanced by the resisting torsion of the suspension. Thus let the charged body *a* (fig. 4) be positively charged; and let the pairs of quadrants be charged differently, so that the ones marked AA' have a higher positive charge than the ones marked BB'. Then the charged **body will move so as to come more within the quadrants BB'. If the relative electrifications of the pairs of quadrants is reversed, the charged body will move the other way. The motion is shown and measured by means of a beam of light reflected from a small mirror fixed to the vertical axis of suspension of the body and moving with it.**

Fig. 3.

Fig. 4.

Henceforth we shall use the unqualified words electroscope and electrometer as meaning the gold-leaf electroscope and quadrant electrometer respectively.

We are now in a position to make an accurate study of the phenomena of induction. We shall

* For the plan and distribution of the following article, see the epitome in the concluding paragraph. The word *electric* was coined in the 16th century by William Gilbert from the Gr. *ēlektron*, 'amber.' See AMBER.

suppose, when nothing is said to the contrary, that all our conductors are of one metal, say brass; that they are at the beginning of every experiment insulated and unelectrified; that the electroscope and electrometer quadrants are likewise unelectrified at the beginning of each experiment; and that the dielectric is air.

Experiment I.—Set a cylindrical brass vessel on the electroscope; and let down into it, without coming into contact with it, a positively charged conductor A. It is convenient to hang this charged ball at the end of a short silk thread from the lid of the vessel, the lid itself being lowered or raised by means of a silk thread. As soon as the ball is brought inside the vessel the gold leaves will diverge, as shown in fig. 5; and the vessel B, as regards outside objects, will behave as if positively electrified. Now touch B with the hand or with any non-insulating material connected to earth—in technical language, put the vessel to earth—and the gold leaves will fall together, and all appearance of electrification will be destroyed. Remove the earth connection so as to insulate B once more, and lift away the lid and the attached ball, care being taken to prevent A coming in contact with B. The gold leaves will again diverge, and the vessel B will be found to be negatively electrified.

Fig. 5.

The nature of the charge on the vessel and gold leaves is indicated at once by the approach of an electrified body. If a piece of rubbed sealing-wax or any negatively charged body is brought near, the gold leaves, if negatively electrified, will diverge still more; if positively electrified, will tend to fall together.

In thus charging the vessel B negatively by induction, we have in no way diminished the original positive charge on A; and we may use this same charge an indefinite number of times in charging negatively other bodies like B. No doubt in each body so charged by induction we have a new-formed source of energy; but this has been derived, not from the energy spent in originally charging the ball, but from the energy spent in separating against their mutual attraction the positively charged ball and the negatively charged vessel.

Experiment II.—Begin again as in Experiment I., introducing the charged ball A into B, and putting B to earth, so that the gold leaves fall together. Now connect A with B. No effect will be observed on the electroscope, even though, as in the former experiment, A should be removed. Thus the charge on A has been completely destroyed; hence, there must have been on B, just before the contact was made, an equal but opposite charge. This is, in fact, the very charge which made its presence evident when, in Experiment I., the ball A was removed.

Thus, if a charged body A be completely surrounded by a closed vessel B, which is put to earth and then insulated, the charge induced on B is equal and opposite to the charge on A. To make this induced charge apparent we must remove A.

Experiment III.—Repeat Experiment I., and after having charged B negatively by induction, introduce A into another conductor C, initially without charge and insulated. If C is resting on a gold-leaf electroscope, the gold leaves will diverge with positive electrification as in the earlier stage of Experiment I. Bring now A into metallic connection with C. If C *completely* surrounds A, no change will be observed on the electroscope, although a spark may be heard at the instant the contact is made. The ball A, if removed without again coming in contact with C, will be found to have lost all its charge; and if B and C are brought into metallic connection, all appearance of electrification on them also will be destroyed. In other words, the negative charge induced on B has been quite destroyed by union with the positive charge transferred to C. These charges therefore must be equal and opposite. Thus, the charge originally on A has been wholly transferred to C.

We conclude, then, that when a conductor is electrified, its electrification resides wholly on the surface. Any portion of it removed from the inside will be found unelectrified if taken quite out of the influence of other electrified bodies.

This experiment, or one very similar to it, was first performed in 1772 by Henry Cavendish, who deduced from it by rigorous mathematical reasoning that 'electric attraction and repulsion must be inversely as the square of the distance.' He inclosed a metal globe within a hollow conducting shell which was built up of two hemispheres. The globe and shell were connected by a wire and charged. The globe was then disconnected from the shell, and immediately thereafter the hemispheres forming the shell were drawn asunder. The globe, now left exposed, was tested for electrification; and, to the degree of accuracy of the experiment, none was found.

Maxwell repeated the experiment in a much more delicate manner than was possible before the invention of the quadrant electrometer. During the charging of the shell and inclosed globe, these were connected by a short wire 'fastened to a small metal disc hinged to the shell, and acting as a lid to a small hole in it.' After the charging, this lid was lifted up by means of a silk thread, and the communication between the shell and the globe done away with. The shell was then discharged and kept connected to earth. Through the small hole in the shell a wire was led connecting the globe with one electrode of the quadrant electrometer. Not the slightest deflection could be observed.

It is impossible then to charge a body by placing it inside a charged conductor. In other words, there is no electric field within any region bounded by a conducting surface, however much that surface may itself be charged, unless there be within that region other insulated and independently charged bodies. It matters not what electrical phenomena may be taking place in the region outside such a conducting surface, such external electrical phenomena have absolutely no internal electrical effect; and *vice versâ*, any purely internal electrical change can produce no external electric effect. In short, any closed conducting surface divides space into two regions, which are electrically independent the one of the other—i.e. so far as electrical action through either is concerned. This principle is taken advantage of in the construction of the quadrant electrometer, the essential internal arrangements of the instrument being inclosed as far as possible within a conducting vessel, the quadrants communicating with external space only by means of their electrodes.

Experiment IV.—The conclusions just stated may be easily illustrated by use of the quadrant electrometer. Thus, as in Experiment I., let the positively charged body A be introduced into an insulated and initially unelectrified closed conductor B. Then, as we know, B becomes electrified, and the region round B becomes an electric field. The condition of this electric field may be studied by means of a small sphere C, joined by a long thin wire to one electrode—i.e. to one pair of quadrants—of the electrometer E. The other electrode is supposed to be kept connected to earth. Before A was introduced into B, the electrometer showed no sign of electrification. But as soon as A is introduced into B, C and its connected quadrants become electrified. The deflection produced on the electrometer will depend upon the position of C with regard to B and upon the original charge of A. It is quite independent, however, of the particular position of A, which may be moved about inside B without in any way affecting the deflection on the electrometer. A may even be brought into contact with B (as in Experiment III.) so as completely to lose its charge; and yet the electrification of C, as shown on the electrometer,

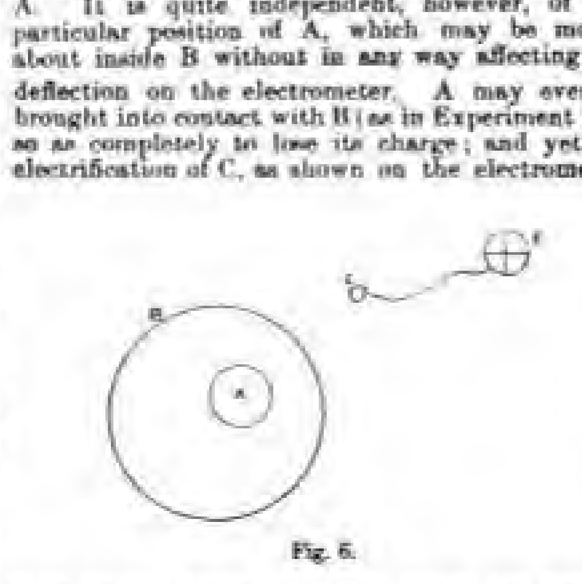


Fig. 6.

is in no way altered—in other words, the electric field outside B is independent altogether of any purely internal changes which may take place inside B.

Suppose, now, that when A has been introduced into B, and a corresponding deflection obtained on the electrometer, B is put to earth. At once the electric field around B is destroyed, C and its connected quadrants recover their original unelectrified condition, and the electrometer gives zero deflection on its scale. Thus the charge on A is completely masked by being surrounded by a closed conductor put to earth.

Further, let B be insulated again and A removed with its charge—then, as we already know, B will be left negatively electrified. The region round B will again become an electric field, and C and its connected quadrants once more electrified. But the deflection on the electrometer, though equal to that first obtained, will be in the opposite direction, opposite because of the opposite character of B's electrification.

This experiment may be taken as an illustration of one of the most fundamental facts in electrostatics—viz. that the generation of so much positive electrification implies the generation of as much negative electrification. Here is a conductor B apparently without charge. Remove from it by any process a positive charge, and an equal negative charge is left behind. The same is true when bodies are electrified by friction, as may be proved by operating inside a closed insulated conductor joined to one electrode of the electrometer. The most energetic rubbing of the two bodies, and their subsequent separation, each in a highly electrified condition, produce no effect whatever on the electrometer—thus showing that their inductive effects on the inclosing conductor are equal and opposite—i.e. their charges are equal and opposite.

Experiment V.—To study in greater detail the properties of the electric field around a given charged conductor B, take two small insulated spheres and connect them by thin wires to the electrodes of the electrometer, each to one. Suppose these spheres to be at first in close contact at some part of the field; then, since the pairs of quadrants are in the same electrical condition, the electrometer will show zero deflection. Now gently separate the spheres, both insulated of course, and in general a deflection to the right or to the left will be obtained on the electrometer. By trial we may find the unique direction of separation which, for a given distance of separation, gives the maximum deflection. This will be to the right or to the left according to the relative position of the two spheres. It will be found, however, that a separation of the spheres in directions at right angles to this unique direction does not cause any deflection on the electrometer. It is far easier indeed to find these directions of separation for which there is no deflection than to find the direction of maximum deflection for a given separation. Suppose in fact that the one small sphere is fixed in position, and that the other, which we may call the exploring sphere, is moved away from contact with it in such a manner that the electrometer always shows zero deflection. The centre of the exploring sphere will describe a curve, and can be made by successive trials to describe an infinity of curves, all lying on a certain surface which passes through the centre of the fixed sphere. We shall call this the surface S. Now with the exploring sphere lying anywhere on this surface, let the fixed sphere be shifted in towards B till the electrometer deflection is unity. Then shift the exploring sphere correspondingly until the deflection is brought back to zero again, and proceed as in the first position to trace out a second surface, which we shall call S + 1, and which will pass through the centre of the fixed sphere in its second position. Shift the fixed sphere once more till unit deflection is obtained, follow up with the exploring sphere, and trace out the third surface S + 2. In this way, step by step, the electric field may be supposed to be mapped out by a series of surfaces, differing in value by unity as measured on the electrometer scale. We may pass out to the surfaces S − 1,

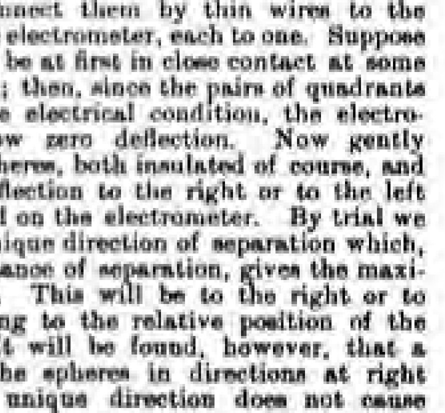


Fig. 7.

S − 2, S − 3, &c., as well as in to the surfaces S + 1, S + 2, S + 3, &c. These surfaces are all closed, and cannot cut each other. For suppose two did cut each other; then, by putting the fixed sphere in the supposed line of intersection, we could move the exploring sphere from the position S to the position S + 1, and produce no change on the electrometer; which is a manifest absurdity, as S + 1 is defined in terms of S *and a change*. If the electrodes of the electrometer terminate on any one of these surfaces there is no deflection; if they terminate on different surfaces the deflection is the difference of the name-values of the surfaces. Evidently the conductor B is such a surface, for if the electrodes terminate on it, all the quadrants, being in metallic connection, will be in the same electrical condition, and the electrometer will show no deflection.

The surfaces we have just described are called *equipotential* surfaces, the term potential having in electricity much the same import as temperature has in heat or pressure in hydrodynamics. When a channel exists between two masses of fluid at different pressures, fluid will flow from where the pressure is higher to where it is lower. Similarly if we have two charged conductors whose electrical conditions as tested by electroscope or electrometer become changed after they have been connected by a wire and disconnected again, these two conductors are said to have been at first at different potentials. If they had been connected to the electrodes of the electrometer, each to one, the electrometer would have shown a deflection; and this deflection would have been a measure of the difference of potential. If the difference of potential is great, then the contact of the two conductors is evidenced by an obvious electrical discharge in the form of a visible audible spark.

If we directed our attention to conductors only, we should not find any special advantage in using the phrase 'difference of potential' instead of 'differently electrified;' but when we follow Faraday in regarding the dielectric as of at least equal importance as the conductor, the conception of the potential is found to be one of peculiar value. Thus any conductor or any system of connected conductors must have all points at the same potential;' whereas, in a dielectric, the potential may vary from point to point, and indeed must vary if the dielectric is separating two conductors at different potentials.

Within such a dielectric we may suppose traced out, after the manner of the last experiment, a series of equipotential surfaces. To fix our ideas, let the one conductor be completely inclosed within the other—say, a spherical globe within a concentric spherical shell—and let this outer shell be put to earth, and let us call its potential zero. Then we know by Experiments II. and IV. that the electric field exists only in the region between the shell and the globe, which we shall suppose to be at a high potential V. The symmetry of the system requires that the other equipotential surfaces will all be spheres concentric with the globe and shell. Now we may compare this electrical system of globe, shell, and intermediate equipotential surfaces to a

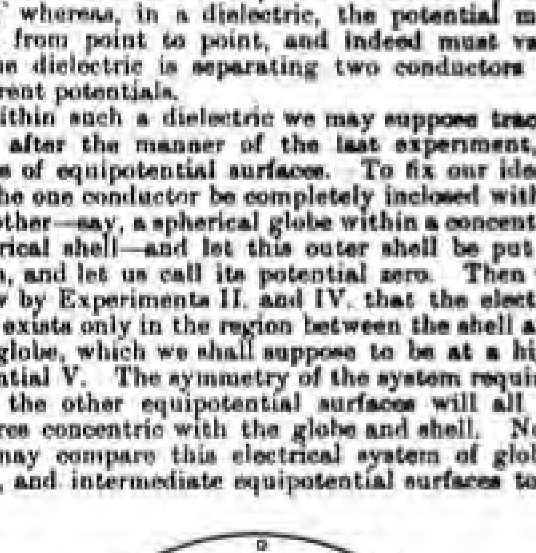


Fig. 8.

system of Contour (q.v.) lines representing a hill with a flat top rising up from the sea-level—the successive equipotential surfaces in the electrical system corresponding to successive equal-level lines in the geographical system. If the substance of the hill were to become fluid, the whole would be reduced to the sea-level, and the contour lines would be effaced. So, if the dielectric were to become conducting, the equal and opposite charges (see Experiments II. and IV.) on the globe and shell would combine and destroy each other, and the electric field with its imaginary equipotential surfaces would cease to exist. Again, to carry one pound of matter from the sea-level up to the top of the hill requires so much work to be done against gravity (see ENERGY), and this amount of work is proportional to the height lifted through—i.e. to the number of contours crossed. So, in the electrical system, to carry a small positive charge from the shell to the globe will require so much work to be done against the electrical forces, and this amount of work will be proportional to the number of equipotential surfaces crossed. Further, exactly as the pound of matter taken to the top of the hill will add to the height of the hill, so will the addition of this small extra charge to the globe increase its potential. We must not, however, push the analogy too far, since in the one case the force of gravity overcome is constant and acts downwards, whereas in the other the electric force varies inversely as the square of the distance from the centre and acts outwards.

We have assumed in the above discussion that the successive equipotential surfaces, experimentally determined by means of the quadrant electrometer, are really such that the work done in carrying a given small charge over the interval separating any two contiguous surfaces is the same. It is usual in treatises on the subject to begin with the dynamical definition of the potential at a point as the work done in carrying a unit of positive electricity from infinity to that point. It is then shown that the quadrant electrometer is an instrument so constructed as to fit in to this definition.

Assuming then that our equipotential surfaces have the property just mentioned, we are in a position to study the energy relations of the electric field.

Coulomb established by experiment that the force of repulsion between two similarly charged bodies was directly as the product of the charges. Hence, as the charge of the globe inclosed in the shell is increased, the electric forces in the field increase in the same proportion. Hence the work done in carrying a given charge from the shell to the globe against the electric forces increases in the same ratio. In other words, the number of equipotential surfaces in the field grows uniformly with the charge. If the potential of the globe is V, we may write the charge CV, C being a constant so long as the geometrical dimensions of the system remain unchanged. Since the shell is always kept connected to earth—i.e. at zero potential, there is a charge − CV distributed over the inside of the shell. To add a small extra charge to the globe may be regarded as equivalent to taking this small charge from the shell, carrying it across the dielectric, and distributing it over the globe. The work done in effecting this is evidently proportional to the charge taken and to the number of equipotential surfaces crossed. But as the extra charge is added, let us suppose, at a steady rate, the potential of the globe is increased at a proportional steady rate. Hence the whole work done in adding a given charge is equal to the product of the charge and the mean potential of the globe during the operation. Thus, in charging the globe from zero potential to potential V, we do an amount of work equal to half the product of the final potential V into the final charge CV—in symbols $\frac{1}{2}CV^2$ or $\frac{1}{2}QV$ or $\frac{1}{2}Q^2/C$, where Q is the charge, and C the constant which depends on the geometrical dimensions of the system.

We have already seen that positive and negative electrifications always co-exist—that it is impossible to generate so much positive charge without at the same time generating as much negative charge. Faraday took implicit account of this truth in his conception of lines of electric force traversing the dielectric. Since no work is done against the electric forces in passing along an equipotential surface, we readily see that the electric force at any point is perpendicular to the equipotential surface there. This direction is, in fact, the unique direction of separation of the two terminal spheres in Experiment V., which, for a given distance of separation, gave the maximum deflection. If, starting from any point, we move always perpendicular to the equipotential surface through which we are for the moment passing, we shall describe a curve which at every point of it is tangential to the direction of the electric force there. Such a curve is called a Line of Force. Take any small area on an equipotential surface, and draw lines of force through its perimeter. These lines of force will form a so-called Tube of Force, whose section in general will vary as we pass along it. Following this tube of force backwards to its source, we shall finally come to a positively charged conductor; and following it forwards we shall ultimately come to a negatively charged conductor. Every such tube of force has, in short, two ends. It springs perpendicularly from a positively charged area, and terminates, also perpendicularly, on a negatively charged area. According to Faraday's view, and to the view now generally accepted, it is along these tubes of force that electric induction takes place; so that the negative charge on the terminal area is exactly equal to the positive charge on the area from which the tube springs.

In the symmetrical system of globe and shell the lines of force are obviously straight radial lines, the tubes of force portions of cones terminated by the spherical surfaces. Some of them are indicated by the dotted lines in fig. 8. If we take each tube as springing from an area bearing unit charge, then there will be in the region as many tubes of force as there are units of charge—i.e. there will be Q(= CV) unit tubes of force. These Q unit tubes of force with the V equipotential surfaces will cut up the dielectric into QV imaginary cells, each of which may be regarded as containing half a unit of energy. In fact, exactly as a stretched piece of india-rubber contains in every element of it so much energy in virtue of the elastic stresses acting throughout it, so we are to regard an electric field as a kind of strain existing in the dielectric, so that in every element of the dielectric so much electrical energy is stored up in virtue of the electric stresses. Every complete unit tube of force contains $\frac{1}{2}$V units of energy; and between any two complete equipotential surfaces differing by unity there are $\frac{1}{2}$Q units of energy stored up. Clearly the electric strain will be greatest where the unit tubes of force are narrowest and where the equipotential surfaces are closest.

Suppose, now, that in the region between the globe and shell an insulated conductor originally unelectrified is introduced; or, what comes to the same thing, suppose a marked off region in the electric field to become conducting, this region will at once be reduced throughout to the same potential, and its surface will form part of an equipotential surface. But, since originally the potential in this region fell steadily as we passed outwards from the globe, a transference of charge must have taken place also outwards in order that the potential should become equalised throughout. The introduced conductor in fact acts as a channel along which electrification is transferred; so that, if tested, the end facing the globe will be found negatively electrified, and the farther end positively electrified.

Now it is evident that the introduction of this conductor into the field has very much changed the configuration of the equipotential surfaces in its vicinity, the new configuration being something like what is indicated in the diagram (fig. 9). As a consequence, the tubes of force, which are necessarily perpendicular to the equipotential surfaces, must also suffer a corresponding change of configuration. A certain

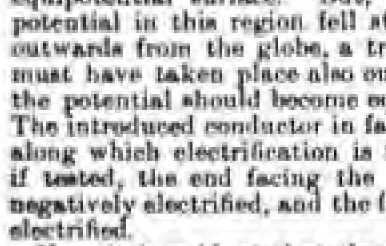


Fig. 9.

number, springing from the globe, will fall perpendicularly on the nearer part of the introduced conductor, while from the farther part an equal number of tubes of force will spring and continue outwards to the shell. Where the tube ends on a conducting surface, there we find unit negative charge; and where it springs from a conducting surface, there we find unit positive charge. Thus, by consideration of the equipotential surfaces and tubes of force, we are led to a conclusion in strict accordance with the experimental truth that an uncharged conductor brought near a charged conductor becomes electrified by induction, so that the nearer end shows an opposite charge, and the farther end shows a similar charge, to that whic!

exists on the charged conductor.

Generally speaking, the effect of the presence of the introduced conductor is to crush the tubes of force in the neighbourhood closer together, and therefore (since this number remains constant) to compel an expansion of them elsewhere. The terminals of the tubes on the globe will obey the same tendency towards concentration and expansion. In other words, the charge Q, at first distributed uniformly over the globe, becomes redistributed and tends to accumulate on the side facing the conductor. The nearer the conductor and globe are brought, the greater will this tendency be: and at last, when they are near enough, the dielectric is unable to sustain the high electric tension along the ever-shrinking tube of force. It yields, a more or less sudden transference of charge takes place in the form usually of a spark, the potentials of the globe and conductor are practically equalised, and the tubes of force between them are annihilated. This is the phenomenon which is exhibited on a large scale in every lightning-flash, and on a small scale in every spark between electrified bodies.

Suppose, however, that before this catastrophe has taken place, the conductor is joined by a wire to the surrounding shell, and consequently brought to zero potential. All those equipotential surfaces which at first inclosed the conductor—i.e. lay between it and the inclosing shell, will be shifted so as to lie between it and the globe. The tubes of force will shift correspondingly; and as no tube can now pass from the conductor to the shell, none will spring from it. Hence the charge on the conductor will be wholly negative. Now experiment shows that when the conductor is brought to zero potential in the way just described, a spark always passes at the instant the connection is made. This spark means so much energy in the form of light, sound, and heat, and must therefore mean a disappearance of energy in some other form. This cannot be other than electrical energy. Consequently the number of unit cells in the dielectric must be diminished. But the charge on A has not changed, so that the number of tubes of force is exactly as before. The change must therefore be in the number of equipotential surfaces; and since the shell and the conductor are at zero potential, the diminution must take place in the potential of A. Thus we see that the potential of a positively charged body is diminished if a conductor at zero potential is brought near it.

This result leads naturally to the discussion of *capacity*. The capacity of a conductor is measured by the ratio of its charge to its potential. Hence if, as in the experiment just described, we have a diminution of potential with constant charge, this is equivalent to an increase of capacity. The greater the capacity of a conductor, the greater the charge it can hold at a given potential. Hence if a number of conductors are at the same potential, the charges must be distributed amongst them directly as the capacities. The experiment just described shows how we may arrange matters so as greatly to increase the capacity of a given conductor. It is sufficient to have close to it another conductor at zero potential. Such an arrangement of conductors is called an *accumulator* or *condenser*; and the most familiar form of accumulator used in electrostatic experiments is the Leyden jar, so called from the city where, in 1745, its properties were accidentally discovered by Cunæus. About the same time, possibly a month or two earlier, almost exactly the same discovery was made by Kleist at Kammin in Pomerania. In its modern form, a Leyden jar is a cylindrical glass bottle, lined inside and outside with metal foil up to within a short distance from the top. A brass rod connected below with the inside coating passes upward through the cork or stopper, and terminates generally in a ball or knob. A Leyden jar then consists essentially of two conductors, the one almost completely inclosed in the other, and separated from it only by the thickness of the dielectric. If either conductor is put to earth, and the other insulated and charged, an opposite and nearly equal charge is induced on the former. If we could completely surround the one conductor by the other, the induced charge would, as we have seen, be exactly equal but opposite to the inducing charge. Leyden jars are indispensable for carrying out illustrative experiments in electricity. When used in combination, they are said to form an electric battery.

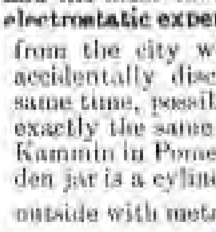


Fig. 10.

The essential nature of the mode of action of an accumulator or condenser may be illustrated as follows: Take any charged conductor with its associated electric field. Let Q be its charge, V_0 its potential, so that $\frac{1}{2}QV_0$ is the measure of the electric energy stored up in the field. Having fixed our attention upon any equipotential surface V_1 inclosing the conductor, let us suppose this surface to become conducting. There will be no transference of charge over this surface, because it is from the very beginning an equipotential surface. There will be no change of the electric field either inside or outside the surface V_1; but these two regions will now be separated by a conducting surface. So far as the outside region is concerned, we may regard the charge Q as distributed over a conductor co-extensive with the conducting surface V_1 (see Experiments III. and IV.), and may quite disregard the existence of the original conductor at potential V_0. The electrical energy stored up in this outside region is therefore a $\frac{1}{2}QV_1$. Let us now connect this new-formed conductor to earth so as to reduce it to zero potential.

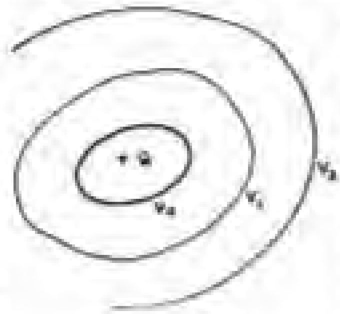


Fig. 11.

By so doing, we discharge the conductor, completely destroying the electric field outside of it and the $\frac{1}{2}QV_1$ units of electric energy stored up in it. This therefore is energy lost to the original system; and the energy stored up in the dielectric separating the two conductors becomes a $\frac{1}{2}Q(V_0 - V_1)$. Now, since the inclosing conductor has been reduced to zero potential, the quantity $(V_0 - V_1)$ must represent the new potential of the inclosed conductor.

In short, the bringing of the inclosing conductor to zero potential, being a purely external electrical change, has in no way altered the *configuration* of the equipotential surfaces and tubes of force inside; it has simply *reduced the potential values* throughout by the same amount—viz. the potential of the inclosing conductor before it was put to earth. The potential of the inclosed conductor has fallen from V_0 to $V_0 - V_1$; and hence, as the charge Q has remained unchanged, the capacity has increased in the ratio $V_0 - V_1 : V_0$. Thus, with either conductor fixed in size, the capacity of the system grows greater and greater as the thickness of the separating dielectric is diminished. If, as in almost all practical cases, the dielectric is very thin compared to the size of the conductors, we may assume that the successive equipotential surfaces come at sensibly equal intervals, so that the surface halfway between the conducting surfaces will have approximately a potential value half-way between the potentials of the conductors. Thus it is easily seen that for a condenser built up of closely opposed surfaces, whether plates or cylinders, separated by a given dielectric, the capacity varies inversely as the thickness of the dielectric.

Take, for example, two concentric spheres, one slightly larger than the other, and let the inner one have a charge Q, and the outer one be at zero potential. The negative charge on the outer sphere will, by a well-known proposition in attractions, exert no electric force throughout its interior. Hence, if a is the mean of the radii of the spheres, we may write Q/a^2 as a very approximate value for the mean electric force acting in the region separating the spheres. If t is the small distance between the two surfaces, the work done in carrying unit charge from the outer to the inner surface is Qt/a^2, the product of the distance into the mean force. This therefore measures the difference of potential of the two spheres, so that a^2/t is the capacity. Now, we shall suppose that t is kept constant, and that a is made to grow indefinitely; then if we write $Q = 4\pi a^2\sigma$, the quantity σ will be the charge on unit area of the inner surface. Hence, ultimately, when the concentric spheres become two parallel planes, the difference of potential between them is measured by the quantity $4\pi\sigma t$, where σ is the charge on unit surface of the one plane, $-\sigma$ the charge on the opposing surface of the other, t the distance between the planes, and π = the ratio of the circumference of a circle to its diameter. The force is measured by the rate at which the potential changes, in this case simply $4\pi\sigma$, and is therefore the same not only at every point between the planes, but also for all values of t.

Now we may calculate the electric force very close to any charged surface on the supposition that the contiguous surface element is part of an infinite plane having the same charge per unit area—in other words, the same surface density. By surface density at any point of a charged conductor we mean the limit of the ratio of the charge on a small element containing the point to the area of the element, as the element is taken smaller and smaller. Such is the quantity σ just discussed.

Thus the electric force just outside a charged conductor is equal to $4\pi\sigma$, where σ is the surface density at the contiguous point of the conductor. It is a repulsion when σ is positive, an attraction when σ is negative.

We may use the result just obtained for finding the force acting on an element of the charged surface itself. Consider the two parallel planes at distance t and difference of potential $4\pi\sigma t$, σ being as above the charge on unit area.

Fig. 12.

Hence the energy stored up in a tube of force stretching from the unit area on B to that on A is $\frac{1}{2}\sigma \times 4\pi\sigma t = 2\pi\sigma^2 t$. Now, with A at zero potential, let B be moved away to double its original distance from A—i.e. through a distance t to B'. If the charge on unit area remains constant, the energy stored up in the corresponding tube of force has become simply doubled, so that there has been an increase in electrical energy represented by the quantity $2\pi\sigma^2 t$. But this must be equivalent to the work done in removing the charge σ through the distance t against the electrical force; hence, the value of this force estimated per unit charge must be $2\pi\sigma$. Thus the force per unit charge acting *on the surface* is just half the electric force acting on unit charge at a point in the field just outside the surface. Otherwise, if F is the electric force at a point just outside a charged surface, $F/4\pi$ is the measure of the surface density at the contiguous surface element, and $\frac{1}{2}F$ is the force per unit charge acting on the surface.

The importance of this result is that it gives us a simple method of measuring electric force in terms of weight. It is the principle of Thomson's absolute electrometer, which is essentially two parallel plates at different potentials, one of which is made so that a small area at its centre is movable under the action of the electrical force. Where this small area is, the electrical system does not differ appreciably from what would be the case if the plates were really infinite. We may suppose the small area suspended by a spiral spring, and that, when the plates are at the same potential, W grammes must be laid on the small area to bring it so that its lower surface is flush with the lower surface of the rest of the upper plate. Let the weight W be removed, and the lower plate be put in connection with the conductor whose potential is to be measured. Now raise or lower this plate until the small area, which with the rest of the upper plate is kept at zero potential, is brought again to be flush with the upper plate. Then we know that the suspension is stretched by a force equal to the weight of W grammes. Now, if the potential of the lower plate is V, and t the distance between the opposed surfaces, V/t is the electric force in the region between the surfaces, and $V/4\pi t$ the measure of the charge on unit area. Hence the force acting on unit area is $\frac{1}{2}V/t \times V/4\pi t$; and finally, if A be the area of the small suspended portion, we have

Fig. 13.

$$W = \frac{V^2A}{8\pi t^2}.$$

In this equation W, A, t are all known, hence V is measured in terms of definite units. In the universally adopted system of scientific dynamic units, we must multiply W by the quantity g, which measures the number of units of force equivalent to the weight of one gramme. Then we find

$$V = t\sqrt{\frac{8\pi g W}{A}}.$$

As a special case, suppose that W is 50 grammes, and A one square centimetre; then, with $g = 981$, we find $V = 1110\,t$, and 88·3 units of charge on the unit area. The unit of charge here referred to is that quantity which when placed at 1 centimetre from an equal quantity will repel it with a force of 1 dyne—i.e. a force which, acting on 1 gramme for 1 second, will increase its velocity by 1 centimetre per second. This quantity is called the electrostatic unit of quantity; and the electrostatic unit of potential is the potential of a sphere of radius 1 centimetre, and charged with this unit quantity.

Generally speaking, except in such obviously symmetrical cases as concentric spheres, infinite co-axial right cylinders, and infinite planes, the surface density will vary from point to point of a conductor, and where it is numerically greatest there also will the electric force close to the surface be greatest. In the case of a simple elongated conductor, the surface density is greatest at the ends. This may be proved very easily by experiment, by, for example, measuring the charge which a very small disc carries away after contact with the conductor. The following reasoning will lead to the same conclusion. Take a uniformly charged sphere in wide space, so that the equipotential surfaces are concentric spheres, and the tubes of force radial cones. If this sphere, by appropriate expansion at right angles to a given diameter, becomes changed into an oblate spheroid, what is the nature of the accompanying change in the surrounding electric field? Let OY be the given diameter, and consider a tube of force symmetrical about any axis OX perpendicular to OY. Let APQB represent this tube of force for the sphere. Along this tube induction takes place, so that the positive charge on PQ would induce an equal negative charge on AXB, if the equipotential surface, of which AXB is a part, were

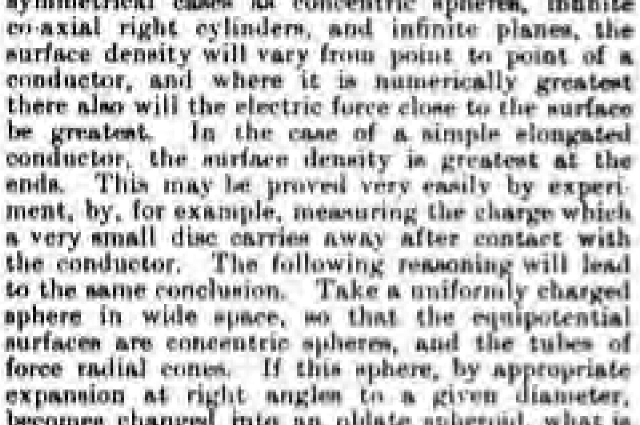


Fig. 14.

to become a conducting surface. We may express this by saying that the electric displacement across any section AXB of a tube of force is equal to the charge on PQ, the area from which the tube springs. Now let the sphere change form in the manner described, but to such a small extent that no appreciable change is produced at the distance OA. The electric displacement across AXB is therefore the same as before; and, if we follow back the tube of force to the conductor, we shall find the corresponding charge distributed over the area from which the tube springs. But, the conductor being itself an equipotential surface, the lines of force must meet it perpendicularly. Hence, near the deformed conductor, each line of force will suffer a displacement as shown in the figure, where AP' represents the new position of what was originally the line of force AP. Similarly the line BQ will bend inwards to the position BQ'. In other words, the tube of force as it springs from the spheroidal surface P'Q' lies wholly within the tube of equal strength which sprang at first from the spherical area PQ. The unit tubes of force which compose the tube which passes through AB are, therefore, more concentrated in the region P'Q' than they were in the region PQ. Hence, the remaining unit tubes of force which spring from the rest of the conducting surface are, taken as a whole, more expanded over the rest of the spheroid than they were over the rest of the sphere. Thus, the average density over P'Q' is greater than the average density over the rest of the spheroid. Now we may suppose this almost spherical spheroid to become elongated little by little. At every step a readjustment of the lines of force will take place, until at length for a pronounced ellipticity they come into the positions P''A'', Q''B''. At a far enough distance, however, these lines of force will be indistinguishable from the original positions PA, QB. Hence, the electric displacement across a far-away section of the tube being as before, the charge on P''Q'' will be the same as that originally borne by PQ. Thus, the more elongated the ellipsoid becomes, the greater is the relative concentration of charge towards the ends. It may be easily shown that the lines of force springing from P''Q'' are branches of a hyperbola confocal with the spheroid, and having PA, QB for asymptotes.

This accumulation of electric charge towards the ends of a pointed conductor is well exemplified in the lightning-conductor, which is simply a very elongated piece of metal in contact with the earth. A charged body of air, such as we have accompanying a thunder-cloud, passes near it. The tubes of inductive force are at once concentrated on the elongated conductor; the electric force at the point becomes so intense that the air can no longer act as a perfect insulator; electrical discharge takes place along these very tense tubes of force; and in a more or less gradual manner the cloud is robbed of its charge, and the evil effects of a sudden lightning-flash minimised. On the same principle, electric discharge through air is facilitated by the use of pointed conductors, such as the combs which are so important a detail in machines for generating electricity by means of friction.

We have seen that the capacity of a condenser depends upon the distance between the surfaces or plates which compose it; it also, however, depends very materially on the nature of the dielectric. Suppose, for example, that we have a series of condensers, made of the same conducting material, and all exactly equal as regards their geometrical and space relations, but all differing as regards the dielectric which separates their plates. Thus let one have air as its dielectric, another plate-glass, another paraffin, another mica, and so on. Let them now all be brought to the same potential, then disconnected and tested as to charge. The charges will be found to be all different—being, in the four cases we have mentioned, approximately proportional to the numbers 1, 6, 2, 6·6. These four numbers are the values of what is termed the *specific inductive capacity* of air, glass, paraffin, and mica. Thus by merely inserting a plate of mica between two plates of an air condenser, we increase the capacity by as much as if we had approached the plates in air through a distance equal to ·85 (= 5·6/6·6) of the thickness of the mica. Otherwise, let there be two metal plates, A, B, separated by a thin plate of mica, and on the other side of A let a third equal-sized plate C be so adjusted that when A is charged, the potentials of B and C shall be equal. This can be readily done by severally connecting B and C to the electrodes of the electrometer, as indicated in the figure. Then it will be found necessary to adjust C so that the distance between A and B is about 6·6 times the distance between A and C.

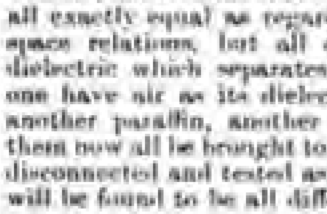


Fig. 15.

We may now fitly consider the principles of action of the various machines that are used for generating electricity. The rubbed pieces of resin, sulphur, glass, &c. were gradually succeeded by spheres, cylinders, and circular plates of these materials, which, as they revolved against prepared rubbers, were kept in a constant state of electrification. Any insulated conductor brought near enough to a portion of such a cylinder or plate at a distance from the rubber will become charged, the dielectric strength of the air breaking down exactly as in the case of the lightning-conductor and the thunder-cloud. Such is the action of the ordinary frictional machine; obviously the conductor acquires a charge similar to that on the revolving cylinder or plate. The opposite charge on the rubber may be transferred to another conductor, which is usually put to earth. Le Roy's or Winter's plate machine is shown in the diagram (fig. 16).

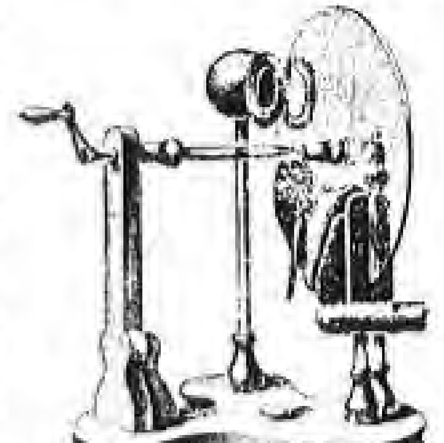


Fig. 16.

Essentially different in its action is the electrophorus, invented by Volta in 1771. In its most improved modern form it consists of two plates, one of metal, and the other of resin, vulcanite, or ebonite backed with metal. Insulating handles can be screwed on to the backs of the plates; and one plate at least must be so insulated. The surface of the ebonite is first electrified by friction, and the metal plate is brought into close contact with it. The metal plate, from its greater proximity to the negatively charged surface of the ebonite, will be at a lower potential than the metal back to the ebonite. If these are then brought into contact—conveniently effected by means of a metal pin passing through the ebonite—a transference of charge will take place, so that the metal plate when lifted away will be found positively charged, while the metal back is left negatively charged. In this machine, the original negative electrification on the rubbed surface of the solid dielectric is used again and again, in accordance with the principles of electrostatic induction and convection, to produce a practically unlimited amount of either kind of electrification.

In Nicholson's 'revolving doubler' we have the parent form of a number of rotatory machines which, like the electrophorus, depend for their action upon induction and convection. They make direct use of the principle of 'doubling' discovered by Bennet, by which the difference of potential between two conductors is indefinitely increased. Thomson's replenisher, which is an important part of the quadrant electrometer in its perfected form, is perhaps the simplest and most compact of these machines. In it, a turning vertical shaft of ebonite bears, at the ends of a horizontal cross-piece of ebonite, two metal pieces called carriers (cc in the diagram, which represents a horizontal section). These carriers rotate in the region between two insulated metal inductors (a, b) in the form of cylindrical segments. When the carriers are in position AB, they come into momentary contact with delicate springs attached to the neighbouring inductors; and when they are in position CD, they come into momentary contact with delicate springs connected by a metallic arc which is quite insulated from the inductors. Suppose a to be at a higher potential than b, and consider what takes place as cc rotates counter-clockwise, as shown by the arrows in the figure. In the position AB, the carriers are well surrounded by the metal shields, and will part with nearly all the charge that may chance to be upon them. Just before they come into contact with the springs in position CD, the two carriers are at different potentials. Hence at the moment of contact with the connecting springs, a transference of charge will take place from the carrier near a to the carrier near b. The former will thus acquire a negative charge, and

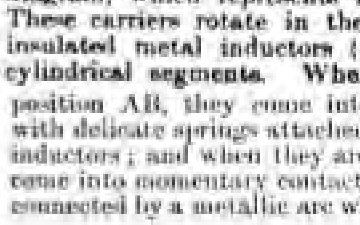


Fig. 17.

will move on till it comes within the inductor b, to which it will give up nearly all its negative charge; while the latter will simultaneously give up nearly all its positive charge to a. Thus every complete revolution each carrier becomes once negatively charged and once positively charged, giving up its negative charge to the one inductor, and its positive charge to the other. The inductors therefore steadily increase in positive and negative charges, or in other words, their difference of potential steadily grows. If the carriers are rotated clockwise, the opposite effect will take place, a acquiring so much negative charge every revolution, and b so much positive charge. In the electrometer, a is in connection with the charged body, which is suspended inside the quadrants. A very elegant contrivance enables the operator at once to tell if this body is charged to its normal condition. If it is undercharged, a few turns of the replenisher in the proper direction will bring the potential up to its proper magnitude; if it is overcharged, a few turns in the reverse direction will bring the potential down to its required value.

The same principles of induction and convection are made use of in the so-called influence machines, which in recent years have quite eclipsed the older frictional machine. These are generally known by the name of their inventors, such as Töpler, Holtz, Bertsch, Voss, and Wimshurst. Of these, the Wimshurst is the latest, and apparently the most satisfactory. It consists of two circular glass plates, mounted on a common spindle, and capable of rotation in opposite directions with equal speeds. Each plate carries twelve or sixteen strips of thin sheet-metal, fixed radially at regular intervals apart. These strips lie on the outside of the closely opposed glass plates. At the extremities of the horizontal diameter of the plates the main conductors are placed, insulated on glass or vulcanite pillars. Horizontal arms with the usual combs project inwards, embracing both plates as far as the inner ends of the metal strips. In front is fixed a diagonal conductor, called a 'neutralising rod;' and a similar rod is fixed behind at right angles to the one in front. These neutralising rods terminate at both ends in a small metal brush, which touches the metal strips or carriers as they pass. By this contact of brushes and strips, every strip on either plate is, very soon after it has passed under the collecting combs, brought into metallic connection for a moment with the strip diametrically opposite it on the same plate.

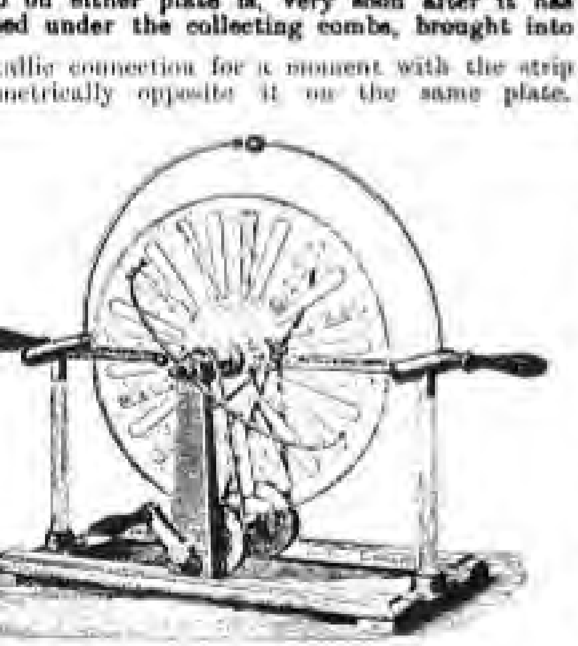


Fig. 18.

Suppose the principal conductors to be at different potentials, then—exactly as in Thomson's replenisher—the carriers as they leave the brushes of the neutralising rod will acquire a charge, negative or positive, according as they are nearer the positively or negatively charged main conductor. But, evidently, each carrier on the one plate will act as inductor to the carriers on the other plate; and a moment's consideration will show that this inductive action will everywhere accentuate the inductive action of the main conductors. Thus the positive conductor is being fed by the positive charges brought by the strips on the upper half of the one plate and on the lower half of the other; while the negative conductor is being fed by the negative charges brought by the strips on the lower half of the one plate and the upper half of the other. The main conductors are provided with arms, which reach out towards each other, and between whose terminal knobs discharge takes place. Sparks, 3 to 5 inches in length, can easily be obtained with this machine.

So far we have confined our attention almost entirely to electrostatic phenomena—*i.e.* to phenomena connected with the existence of a steady electric strain in dielectrics. When compelled to deal with the transference of so-called charge from conductor to conductor, we had regard rather to the initial and final equilibrium conditions than to the intermediate condition of change. This condition of change, however, has clearly very important energy relations. In all cases of electrical discharge there is, in the language of Faraday, a concentration of the lines of force in a certain region of the dielectric, until that becomes, as it were, overstrained, and yields with a more or less evident appearance of part of the energy of strain in the form of light, sound, and heat. The particular manner of transformation into these commoner forms of energy depends on a variety of circumstances, such as the pressure and temperature of the dielectric, the form and relative size of the conductors, and so on. Even if there be no such energy transformations apparent to our senses, it can be shown that any equalisation of potential without increase of total charge necessarily results in a loss of electric energy to the system.

Thus, let there be two insulated conductors of capacities C and C′, originally at different potentials. If they are brought to the same potential V by being connected by a thin wire of comparatively insignificant capacity, the original charges on the conductors will become redistributed, and the final charges will be CV and C′V. Whatever charge the one conductor has lost, the other has gained. Hence we may write the original charges as $CV + q$, $C'V - q$, where q is the charge which has been transferred from C to C′. Now the energy of any charged conductor is measured by half the charge into the potential or half the square of the charge divided by the capacity. Thus the final energy, after equalisation of potentials, is:

$$\tfrac{1}{2}CV^2 + \tfrac{1}{2}C'V^2,$$

while the initial energy was

$$\tfrac{1}{2}\frac{(CV+q)^2}{C} + \tfrac{1}{2}\frac{(C'V-q)^2}{C'} = \tfrac{1}{2}CV^2 + \tfrac{1}{2}C'V^2 + \tfrac{1}{2}q^2\left(\frac{1}{C}+\frac{1}{C'}\right).$$

Hence, since $\tfrac{1}{2}q^2\left(\frac{1}{C}+\frac{1}{C'}\right)$ is always positive, we see that the initial energy is necessarily greater than the final energy. The loss of energy is represented by a quantity which is proportional to the square of the charge that has been transferred. If we look more closely into the significance of this quantity, we see that it represents the electrical energy of the system of two conductors of capacities C and C′ when they are charged each with q units of either positive or negative electricity; or, more particularly, it represents the work which must be done in carrying q units from the one to the other. This is an example of the general principle that the work done by the electric field in compelling a transference or flow of electricity from one region to another is exactly equal to the work which must be done against the electrical forces in carrying an equal quantity of electricity back again.

It is convenient, especially when the flow of electricity is the subject of consideration, to use the term Electromotive Force instead of Difference of Potential. We may suppose it measured by means of the quadrant electrometer. Thus if the regions A and B are connected severally to the electrodes of the electrometer, the deflection will measure the electromotive force acting along any conducting channel which may be supposed to bring A and B into communication. The flow of electricity which this electromotive force compels will tend to bring A and B to the same potential; and in the ultimate vanishing of the deflection on the electrometer we have the evidence of such a flow having taken place. But we may suppose that, by some means, notwithstanding the conducting channel between A and B, their difference of potential is sustained, so that the electromotive force acting along the channel is kept constant. Then the electrometer will show a steady deflection; while at the same time a steady flow of electricity will take place along the channel. This flow, whose existence is indicated only indirectly by the electrometer, must be measured by some one of its direct effects.

These effects are conveniently grouped into physiological, thermal, chemical, and magnetic.

The electric 'shock,' experienced when the experimenter uses himself as a discharging conductor, is a familiar example of the physiological effect of an electric current. The electric discharge causes a muscular contraction. In 1790 Galvani observed that the limb of a frog, when touched simultaneously by two different metals in contact, was convulsed exactly as if subjected to an electric shock; and Volta, following up this observation, discovered in 1800 a new source of electromotive force which could sustain an electric current through a conductor for a lengthened period of time. From this dates the development of Galvanic or Voltaic electricity, or, as it is now more commonly called, current electricity. The electric shock, however, depends upon *variations* in the amount of flow; a steady current produces no shock, except when it is beginning or ending.

In the electric spark there are of course thermal effects; and generally, since, as we have seen, a transference of charge or flow of electricity means a loss of electric energy, an evolution of heat is a necessary consequence.

Towards the close of last century the decomposition of water by an electric discharge was observed by Van Troostwijk and Deiman; while with Volta's electrical discoveries a new era in chemistry as well as in electricity was inaugurated.

None of these effects, however, give a ready method for measuring a steady electric current—i.e. the amount of electricity which is transferred across any section of the conductor in a second, or in any other chosen unit of time. For this we must go to the fourth group—viz. the magnetic effects of currents. This branch of the subject, which includes electro-magnetism, and as a consequence much of electro-dynamics, dates from 1820, when Oersted of Copenhagen discovered the action of a current upon a magnet suspended near it. As a matter of history, the discovery was made by means of voltaic electricity; but that there was some close relation between magnetism and electricity had long been recognised by experimentalists. Lightning had been known to destroy and even reverse the polarity of ships' compasses. Steel and iron had been magnetised by discharging electricity through them; but the effects of such sudden discharges were extremely capricious, and quite baffled all attempts to co-ordinate them. We may, however, by discharging a Leyden jar through a carefully insulated wire suitably coiled round a magnet, show that at the instant of discharge the magnet is displaced.

The broad fact established by Oersted was that every electric current tends to make a magnet set itself perpendicular to the direction of the current. To make the effect specially apparent, the wire conveying the current should be coiled again and again round the region in which the magnet is placed. The same current is thus brought again and again into the vicinity of the magnet, and has a proportionately greater effect. An instrument consisting in this way of a coil of wire surrounding a magnet, free to rotate in some plane passing through the axis of the coil, is called a *galvanometer*. The coiled wire must be covered with gutta-percha, silk, or cotton thread, so that the contiguous coils may be insulated from each other; and, for ordinary purposes, the plane of the coil should contain the magnet when no current is flowing. We may suppose the magnet to be suspended horizontally under the influence of the earth's magnetic field; then the plane of the coil should contain the magnetic meridian (see MAGNETISM). The ends of the coiled wire are called the terminals of the galvanometer. When they are connected to conductors at different potentials, a current will flow round the coil of wire, and will indicate its presence by compelling the magnet to move out of its normal position of equilibrium. The tendency of the current in the coil is to make the magnet turn itself at right angles to the plane of the coil—i.e. to set itself along the axis of the coil, magnetic east and west. But this is resisted by the steady action of the earth's magnetic field. The result is a compromise, and the magnet is deflected from its normal position in the magnetic meridian through an angle which depends on the relative values of the current and the earth's magnetic force. Since the latter is practically constant, the angle of deflection will depend on the value of the current, being greater for the greater current. It is not our purpose under this heading to enter into the magnetic relations of currents. For that we refer to MAGNETISM. It is sufficient at present to know that in the galvanometer we have an instrument which can measure current, exactly as in the electrometer we have an instrument which can measure difference of potential or electromotive force.

In discussing the equalisation of potential in electrostatics, we purposely confined our attention to one metal only. The reason was simply because, in general, two different metals, or in fact any two different conductors, can never when in direct contact be at the same potential. The discovery of this fact we owe to Volta. Take, for instance, any four conductors BAXB, put them in series as in the figure, and connect the terminal members, which are of the same material, to the electrometer. According to the character of the conductors AXB, there may be, or there may not be, a deflection on the electrometer.

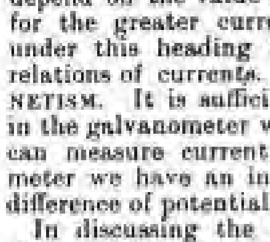


Fig. 19.

(1) If there is no deflection, the two B's are at the same potential; and yet, according to Volta's discovery, the three different substances are at different potentials. This may be shown at once by breaking the chain at any of the separating surfaces, when a deflection on the electrometer will be observed. During this act of separation, the separating surfaces, one of which must of course be kept insulated, act like a condenser with a constant charge, the difference of potential changing because the capacity is changing. The reason why the B's are at the same potential is that, whatever be the differences of potential between B and A and between A and X, the difference of potential between X and B is always such as to restore B to its original value. Thus if the separation of B and A gives a deflection of 20 to the right on the electrometer, and the separation of A and X gives a deflection of 8 to the left, the separation of X and B is found to give a deflection of 12 to the left.

(2) If, however, there is a deflection produced on the electrometer, then we know that the two B's must be at different potentials, so that, if we connect them by wires to the terminals of the galvanometer, a current will be observed to flow. Such a combination of materials, in which two conductors of the same material are kept at different potentials by being linked together by at least two other and different materials, is called a voltaic or galvanic cell. If we join the two terminals either directly or by means of any other simple conductor, a current will necessarily flow round the circuit. But this current means a transference of charge from one conductor to another at a lower potential—i.e. a loss of electrical energy which is proportional to the square of the quantity transferred. Hence, if, as is practically the case, the electromotive force or difference of potential remains fairly steady, it must be because electrical energy is supplied as fast as it is being lost. Consequently there must be in the circuit somewhere an original source of energy. In fact it is found that a permanent electromotive force of the kind just described is always associated with a tendency to chemical action between two at least of the members of the chain; and that, when the circuit is complete and the current is flowing, chemical changes are going on within the cell. In this case, also, we may, by separating the chain at its various surfaces, show that at every surface there is an electromotive force of contact sustaining a difference of potential. But whereas, in the former case, the algebraic sum of all the differences of potential between the successive pairs of materials as we pass along the chain from B to B vanishes identically, in the present case it has a finite value, which is the total electromotive force of the combination as measured on the electrometer. A combination of two or more voltaic cells is commonly called a voltaic or galvanic battery.

There are innumerable forms of voltaic cells, built up in different ways of different materials. Copper and zinc dipping into dilute sulphuric acid is one of the simplest forms. When the cell is *closed*—i.e. when the copper and zinc are joined externally by a wire, a current will be obtained flowing in the wire from the copper to the zinc. At the same time the zinc will be dissolved in the acid; and it is from the energy set free by this chemical action that the electrical energy is derived. Such a single fluid cell is not, however, very steady in its action. We shall therefore take as a type of a good cell one of the class known as two-fluid cells; and of these we shall choose the Daniell cell. In its best form, the Daniell cell consists of copper and zinc plates dipping into saturated solution of sulphate of copper and semi-saturated solution of sulphate of zinc respectively—the liquids being also in contact but prevented from mixing by a porous septum. Connect the copper and zinc plates, or *poles* as they are technically called, to the electrometer. A deflection will be produced which will measure the electromotive force of a Daniell cell when it is not being used for the production of currents—i.e. when it is *open*. We shall take this, provisionally, as our unit electromotive force, and we may suppose the electrometer scale graduated so as to show unit deflection when the poles of a Daniell cell are connected to the electrodes of the electrometer. The deflection is such as to indicate that the electrode connected to the copper is at the higher potential. Hence the copper is spoken of as the positive pole, and the zinc as the negative pole.

Take now a second Daniell cell, connect its zinc to the copper of the first one, and connect the free poles to the electrometer. The electromotive force of the two cells so joined will be double that of one—i.e. equal to 2. And generally, when a number of cells are arranged in *series* (i.e. with the zinc of the first joined to the copper of the second, the zinc of the second to the copper of the third, and so on), the electromotive force of this battery, in terms of the electromotive force of one cell, is just the number of cells composing it. Theoretically there is no limit to the electromotive force obtainable by means of cells; practically the difficulty consists in keeping a large number of cells in good condition. With a large enough battery we can obtain effects in every way analogous to the effects produced with frictional electricity. The electric light in its earliest form was obtained between carbon terminals joined to the poles of a large battery of cells. Generally speaking, however, the differences of potential in electrostatic experiments are much greater than the electromotive forces commonly used in experiments with electric currents. Thus, the electromotive force of a Daniell cell is very much smaller than the electrostatic unit of potential as measured on Thomson's absolute electrometer in the manner previously described. It would require a battery of about 278 Daniell cells set in series before the electrostatic unit of potential could be obtained; and it would require the use of about 10,400 cells in series to compel a spark to pass directly between two parallel plates connected to the poles and distant one-third of a centimetre from each other. With such comparatively small electromotive forces many substances can be used as insulators in current electricity which are fairly good conductors in electrostatics.

If, at the same time that the poles of a cell are connected to the electrometer, they are connected by stout short wires to the terminals of the galvanometer, the galvanometer needle will be deflected, while the electrometer deflection will be unchanged, or at the most diminished slightly. If thin long wires are substituted for the thick short connections, a very great diminution will be observed in the galvanometer reading, and perhaps a very slight increase in the electrometer reading, the apparent electromotive force of the closed cell approximating more closely to the electromotive force of the open cell. Thus, we may alter the current at will by employing different lengths and different thicknesses of wires for transmitting the current; and yet the electromotive force between the poles of the cell is but slightly if at all affected. In other words, the current, as measured on a galvanometer, depends not only on the electromotive force acting along the channel, but upon some property of the channel itself—some property independent altogether of electromotive force.

This property we may indicate by either of two words—viz. Conductivity or Resistance. These words denote contraries. Thus, a body of small conductivity has a great resistance; and a body of low resistance has a high conductivity. Quantitatively, the one is the reciprocal of the other; and they are measured in terms of current and electromotive force by what is known as Ohm's Law. We now know (see *The Electrical Researches of the Hon. Henry Cavendish*, edited by Maxwell, 1879) that Cavendish had in 1781 established this law, and compared the resistances of iron wire and various saline solutions to electric discharge through them. He acted as his own galvanometer, and compared discharges by their 'shocks.' As regards the historical development of the science, however, it is to Ohm that we owe the full statement of the Law (1827). Since his day it has been subjected to the severest experimental tests that the scientific mind could imagine, and has stood them all. It is really the basis of our whole system of electrical measurements; and is to electric currents what the law of gravitation is to planetary motions. Ohm's Law asserts that the resistance of a conductor is measured by the ratio of the electromotive force between its two ends to the current flowing through it. Thus, if E is the electromotive force as measured on the electrometer, and I the current as measured on the galvanometer, and if K, R measure the conductivity and resistance respectively, Ohm's Law gives us these relations:

$$EK = I, \quad E = IR.$$

The Law is purely empirical. Assuming its truth, we shall here deduce from it certain relations, which experiment accurately verifies.

The peculiar value of Ohm's Law lies in the fact that the property designated resistance, though measured in terms of electromotive force and current, is absolutely independent of them. Hence so long as the physical condition, and therefore the resistance, of each conductor remains unaltered, the currents in any system of conductors are proportional to the electromotive forces; steady currents imply steady electromotive forces; steady electromotive forces imply steady currents. And thus, if the potential at one point is steady, the potentials at all other points will be steady; and this means that whatever quantity of electricity flows into a point must flow out again—for otherwise there would be a gain or loss of charge at that point, and therefore a change of potential, which is not contemplated. In the particular case of a single circuit, it follows that the current is the same at every part of it, and must therefore be regarded as flowing through the Daniell cell from the zinc to the copper, as well as through the rest of the circuit from the copper to the zinc.

If a steady current is flowing along a conductor of one kind of material, say a copper wire, the potential will fall off continuously as we pass along in the direction of the current. Let AB be the wire, and suppose the current to be flowing from A to B. Join B to one electrode of the electrometer; and let a wire from the other electrode be led to any point P on the wire. Then as the point of contact P is moved up towards A, the electrometer deflection will increase continuously. Even though AB is not all of one material, the same steady growth of the electrometer deflection will be shown as the point P is made to travel from B to A. Thus suppose AC to be zinc, and CB to be copper, and no current to be flowing; then according to Volta's discovery the potential, otherwise constant, will undergo an abrupt change at the surface of separation at C. But, as we have seen, the brass quadrants of the electrometer will not on this account be at different potentials, even though P lies in AC. Hence, if any difference of potential *shows itself on the electrometer*, it must be because a current is flowing along AB. Thus we may extend Ohm's Law to heterogeneous circuits.

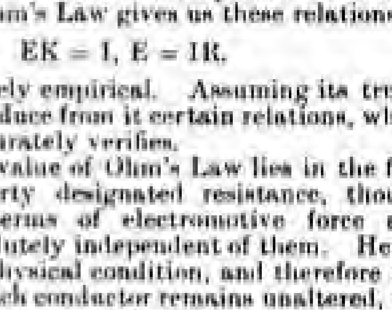


Fig. 20.

The measurement or, more strictly, comparison of resistances is one of the most important operations in the modern science of electricity. For this purpose we first choose a certain standard, say a particular length of a particular piece of wire at a certain temperature. It is obviously convenient to have a standard which can be exactly reproduced should the first standard be lost or in any way damaged. Hence scientific men of all nations have agreed to use as the unit of resistance the resistance of a column of pure mercury 106 millimetres long, 1 square millimetre in cross-section, at the temperature of melting ice. This is called the *legal ohm*. It differs very slightly from the theoretic ohm, which is defined in terms of what are called the electro-magnetic units of current and electromotive force. See MAGNETISM.

Such a mercury standard, though fulfilling the very necessary condition of accurate reproduction, is not convenient for practical use. For this purpose copies of the ohm must be made in solid wires of some metal or alloy. German silver has long been a favourite substance for making such practical standards; and of late a somewhat similar alloy called *platinoid* has come into use. Ohm's Law at once suggests a method for copying the standard mercury ohm. First, let the mercury column be included in a circuit with a given battery and galvanometer, and the deflection on the galvanometer noted. Second, let the mercury column be replaced by a wire, and the length of the wire adjusted till the galvanometer shows the same current. Then, provided that the electromotive force of the battery is the same in the two cases, the resistance of the substituted length of wire is 1 ohm. We may obviously construct an indefinite number of such copied standards.

If we put any number of these single ohms end to end in series, we shall get a whole resistance equal to as many ohms as there are conductors. This is an immediate consequence of Ohm's Law. For since it is the same current that is flowing through all the single ohms, the fall of potential as we pass from beginning to end of any one is the same for all; hence, the fall of potential as we pass along, say, three is three times the fall as we pass along one; hence, the current being the same for the three as for the one, the resistance of the three must be 3 ohms. A special case of this is that the resistance of a wire, otherwise constant in its physical relations, is directly as the length. The completely general statement is that the resistance of any single continuous channel is the sum of the resistances of its parts.

Suppose, however, that the single ohms are so arranged that they all begin at one point, A, in the circuit, and end at another point, B. Then it is clear that they must all be traversed not by the same current, but by equal currents. Hence, there will flow into A and out of B a current equal to the sum of all these equal currents. Thus, if there are, say, three single ohms connecting A and B, the total current flowing into A and out of B must be three times the current flowing in any one of the branches. But for constant electromotive force the current is directly as the conductivity, or inversely as the resistance. Hence, the conductivity of the threefold conductor between A and B is three times the conductivity of any one of its components; or, otherwise, the resistance between A and B is one-third of an ohm. Here, again, as a special case, we find that the resistance of a wire, otherwise constant in its physical relations, is inversely as the area of its cross-section. The completely general statement is that the conductivity of a multiple channel whose branches all begin at one point and end at another, is the sum of the conductivities of the branches. These multiple-arc arrangements, as they are technically called, are of peculiar value in all electrical investigations and applications. Cavendish, who states the law of the double-branch circuit with particular accuracy, was the first experimenter who used the arrangement. By discharging a Leyden jar through a branch circuit consisting of an iron wire and his own body he obtained a certain sensation, which he compared with the sensation produced when a column of salt water was substituted for the iron wire. By adjusting the length of the salt-water column until the two shocks felt equally intense, he had data from which a comparison of the resistances of iron and salt water could be made. This comparison Cavendish gave in a paper published in 1776, without, however, giving his method of experiment, which lay hidden in the unpublished manuscripts for fully a century. His result was that iron conducts 555,555 times better than saturated solution of salt, a result in remarkable agreement with modern galvanometer measurements. In comparing resistances of *materials*, we must find the resistances of portions which have the same length and the same cross-section. The results given above, connecting the measured resistance of a conductor with its dimensions, enable us to effect this comparison without difficulty. Thus, if r is the resistance of a wire of length l, and cross-section s, the quantity rs/l evidently measures the resistance of a wire of unit length and unit cross-section. If the unit length is a centimetre, and the unit area a square centimetre, the quantity which measures this resistance is called the *specific resistance* of the material. The substance which has the smallest specific resistance is the best conductor of electricity. The best conductor is silver; but copper is nearly as good. The specific resistance of iron is nearly six times that of copper, and that of mercury nearly sixty times.

Fig. 21.

In Cavendish's experiment just described, the iron wire acted as a *shunt* in the circuit of jar and body; for the resistance of the iron wire was much less than the resistance of the body. Hence, the discharge through the wire was proportionately greater than the discharge through the body. In a double-branch circuit the current divides itself into two parts, which by Ohm's Law must be directly as the conductivities of the branches. If we put the galvanometer in one of the branches, we may, by adjusting the resistance in the other branch, vary the current in the galvanometer through a very large range, while the total current supplied by the battery remains constant. Let AB be a wire of unit resistance, forming part of a circuit; and let the points AB be connected to the terminals of the galvanometer, whose resistance we shall suppose to be very great compared to the resistance of the wire AB, say, 5000 ohms. If i is the current as measured on the galvanometer, $5000\ i$ is the electromotive force acting along AB; and this multiplied by the conductivity of the double-branch portion lying between A and B will give the total current entering at A and leaving at B. The conductivities are 1 and $\frac{1}{5000}$ respectively, so that $\frac{5001}{5000}$ is the conductivity of the whole; and, hence, $5001\ i$ is the total current supplied by the battery. Suppose, now, that instead of connecting the galvanometer terminal with B, we connect it with B′, where BB′ represents another ohm of resistance. Then if i' is the current in the galvanometer, we have $5000\ i'$ as the electromotive force between A and B′. The conductivity of the double-branch portion is now $\frac{1}{2} + \frac{1}{5000}$, i.e. $\frac{2501}{5000}$; hence, the current supplied by the battery is $2501\ i'$. But in almost all cases of importance—except when extremely accurate results are wanted—the fourth significant figure in any number is negligible. Indeed, very few galvanometers can be trusted to measure currents to such an extreme of accuracy. Hence, the resistance of the whole circuit is practically the same so far as the possible measurement of current is concerned—i.e. the currents $5001\ i$ and $2501\ i'$ are equal; and, hence, to the degree of approximation stated $i' = 2i$. In short, the galvanometer of high resistance used in the way just described, in which the main current is shunted through a comparatively small resistance, really measures the electromotive force between the ends of the shunt. For many purposes we may use such a high-resistance galvanometer instead of the electrometer.

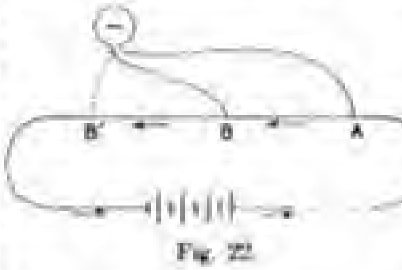


Fig. 22.

From what has just been said regarding the accuracy to which a galvanometer deflection may be read, it is evident that if the comparison of resistances depended on the *measurement* of current, it would be impossible to compare resistances to any very great degree of accuracy. The comparison of resistances may, however, be effected by the method known as the Wheatstone bridge, without so much as a single measurement of either electromotive force or current.

Consider the case represented in fig. 23, in which the current from a battery is made to flow along two distinct channels from A to B. Along each the potential falls from its value a at A to its value b at B. Hence, for any point P in the one branch there must be a corresponding point Q in the other which has the same potential, v, say. Let the points P and Q be joined to the terminals of the galvanometer, G. Because of the equality of the potentials at P and Q, no current will flow through the galvanometer, however strong the currents may be in APB and AQB. Thus, as no current flows between P and Q, the current in AP must be the same as the current in PB, and the current in AQ must be the same as the current in QB. Hence, by Ohm's Law, the resistances of AP and PB must be proportional to the electromotive forces acting along them—i.e. in the ratio $(a - v)/(v - b)$. Similarly the same ratio expresses the ratio of the resistances of AQ and QB. Thus the existence of no current in the galvanometer circuit—a condition which admits of the most delicate of tests—implies that the resistances of the four branches AP, AQ, PB, QB form a simple proportion, any one forming the fourth proportional to the other three properly taken. Two equal lengths cut off from a fairly uniform wire may be assumed to have approximately equal resistances. Let them be the branches AP, AQ. Let PB be the standard ohm. Then, by adjusting the length QB of a given wire till no current flows through the galvanometer, we obtain a copy of the ohm, accurate if the resistances AP and AQ are really equal to each other. Suppose, however, that they are not quite equal, but that AP/AQ is equal to $1 + \omega$, where ω is usually a small quantity, and that therefore $AQ/AP = 1/(1 + \omega)$. Let l be the length of wire required in QB when the standard ohm is in PB, so as to satisfy the condition of no current in PQ; and let l' be the length of the same wire required in PB when the standard ohm is in QB, so as to fulfil the same condition. The lengths l and l' will differ so slightly that we may assume them to be accurately proportional to their resistances. If L is the length of wire whose resistance is accurately 1 ohm, then evidently

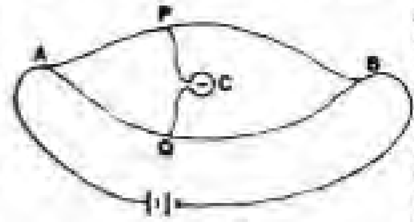


Fig. 23.

$$l = \mathrm{L}\,(1 + \omega)^{-1},\ l' = \mathrm{L}\,(1 + \omega);$$

and hence, multiplying we find

$$ll' = \mathrm{L}^2\,;$$

or the length of wire whose resistance is 1 ohm is the geometric mean between the lengths whose resistances balanced the standard ohm in the two cases described. This discussion is an illustration how, from a first approximation, a second and much closer approximation can be obtained.

To facilitate operations in the measurement of resistance, it is expedient to construct a series of graded resistances, which are multiples and occasionally submultiples of the chosen unit of resistance. We may obtain, in the manner just described, any number of copies of the ohm. Then, by putting two in series in the one arm of the Wheatstone bridge, we can measure off a piece of wire having a resistance of 2 ohms; and so on, step by step, we can measure off lengths of suitable wires whose resistances will be any imaginable number of ohms. Again, by putting in the arms AP, AQ very different resistances, say 10 ohms and 1 ohm, we can construct resistances of fractions of an ohm—e.g. if PB is 1 ohm, QB will be the tenth of an ohm. For such fractional resistances thick wires or many strands of thin wires in multiple arc must be used. For the higher resistances thin wires are convenient. Suppose we have, in this way, constructed resistances having the values 1, 2, 3, 4, 10, 20, 30, 40, 100, 200, 300, 400, 1000, 2000, 3000, 4000, 10,000, 20,000, 30,000, 40,000; then we may by proper combination express any integral number of ohms from 1 up to 100,000. Thus, the resistance 7956 is built up of 4000, 3000, 400, 300, 200, 40, 10, 4, 2. There are several ways in which these twenty resistances can be arranged so as to admit of rapid combination of any required number. Such an arrangement is called a box of resistance coils, or simply a resistance box. It is an indispensable part of the apparatus of a physical laboratory.

We have already seen that the passage of an electric current means a loss of electric energy. What becomes of this energy—i.e. into what other form is it transformed—is a question which requires to be answered. The answer was fully given by Joule of Manchester in a magnificent series of experiments on the heating effects of electric currents. It was early recognised that the electric current and electric discharge had a heating effect on the conductor along which the current flowed or the discharge took place. As early as 1801, very soon after the discovery of voltaic electricity, Wollaston exhibited before the Royal Society the glowing of a thin wire joining the poles of a cell. To Joule, however, we owe the complete statement of the irreversible heating effects of currents. In 1840 he published the important result that 'when a current of voltaic electricity is propagated along a metallic conductor, the heat evolved in a given time is proportional to the resistance of the conductor multiplied by the square of the electric intensity.' The heat so evolved fully accounts for the electric energy lost. Suppose we have an electromotive force E driving a current I through a resistance R. E is the measure of the work done in transferring unit of electricity along the channel. Now I is the amount of electricity transferred in a second of time. Hence the product EI measures the work done per second by the electromotive force in driving the current I. But by Ohm's Law

$$EI = RI^2;$$

and this is the very quantity which Joule showed appeared as heat in the wire. Here evidently we have a thermal method for comparing resistances. Set the various conductors in series, so that they are traversed by the same current. Then the resistances are proportional to the heats developed in them. To measure the heats so evolved we must know the rise of temperature and the thermal capacity of each conductor.

If a very thin wire forms a part of a circuit, it is there that we shall best observe the effect of the heating. For the heat evolved per unit length of any conductor is directly as the resistance—i.e. inversely as the cross-section. But, with the circuit all of one material, the rise of temperature is directly as the heat evolved and inversely as the mass heated; and the mass per unit length is directly as the cross-section. Thus the rise of temperature is inversely as the square of the cross-section—i.e. inversely as the fourth power of the diameter.

This is the principle of construction of the incandescent electric lamp, now so common a source of illumination (see ELECTRIC LIGHT). A thin filament of carbon is made to glow by the passage of a powerful current along it. To prevent the 'burning' away of the carbon in air, it is inclosed in a hermetically sealed glass vessel quite empty of oxygen.

As an example of the magnitude of the Joule effect in a conductor of given resistance traversed by a given current, let us take a resistance of 10 ohms, along which the electromotive force is equal to that of one Daniell cell, then the heat evolved in an hour will be about 100 gramme-degree units of heat—i.e. an amount of heat capable of raising the temperature of 100 grammes of water by 1° centigrade.

So long as we are dealing with metals or simple conductors like carbon, the currents derived from the Daniell cells in the circuit do not appreciably change in value from the first instant onwards for several hours. If the currents are powerful enough, there will be slight diminution during the first few minutes, due to the heating of the conductors; for the resistance of nearly all metals increases with rise of temperature. But this effect will not in general be appreciable.

A very different set of phenomena confronts us when we introduce into the circuit a conductor like a solution of sulphuric acid, or of any sulphate, or indeed any ordinary chemical compound, either in solution or in a state of fusion. Such conductors can transmit currents only at the expense of their constitution; or, in the words of Faraday, in them 'the power of transmitting the electricity across the substance is dependent upon their capability of suffering decomposition.' Such substances—the whole terminology of the subject was introduced in 1834 by Faraday—are called *electrolytes*; the conductors by which the current enters and leaves the electrolyte, the *electrodes*; and the whole process by which chemical compounds are decomposed by means of electric currents is named *electrolysis*.

Take, for example, a dilute solution of sulphuric acid nearly filling a glass vessel. Dip into this electrolyte two platinum strips, some little distance apart and not touching. These are the electrodes; and it is important in such an experiment to choose as electrodes materials for which the electrolyte has no chemical affinity. In this respect platinum is, over all, by far the most satisfactory. Now connect the one platinum strip to one pole of a Daniell cell, and the other to one of the terminals of the galvanometer. The other terminal of the galvanometer and the other pole of the cell may be connected at will, so as to complete the circuit. When in this way the circuit is completed, a current will be observed flowing through the galvanometer; but this current will very soon become extremely feeble, and, even though it may not altogether vanish, will produce no continuous decomposition of the fluid. Let now a second Daniell cell be added as shown in fig. 24, where B is the battery of two Daniell cells, G is the galvanometer, and C is the electrolyte. Then the galvanometer will indicate the existence of a pronounced current, which during the first few moments will fall considerably below its original intensity, but will ultimately reach a steady value. At the same time small bubbles of gas will appear at the surfaces of both electrodes, and will form steady ascending streams in the electrolyte. These products, or *ions* as Faraday called them, may be collected in separate vessels, as shown in fig. 27, where the gases accumulate at the top of test-tubes inverted over the electrodes, gradually pushing out the liquid which at first filled these tubes. It will be noticed that the volume of gas given off from the one electrode is twice that given off from the other; so that if the test-tubes are exactly the same size, the one will become quite emptied of liquid when the other is only half-emptied. The greater volume of gas accumulates over the electrode by which the current leaves the electrolyte. When tested, the gas which comes off in greater quantity will be found to be hydrogen, and the other oxygen. In fact we have here separated from one another the constituents of water—H_2O. We may therefore say that, whatever the intermediate stages of the process may be, the final result of passing a current through dilute sulphuric acid is to decompose water.

Fig. 24.

The characteristic points to be noticed here are that one Daniell cell cannot decompose water; that when two or more are used, the current markedly falls off in intensity during the first few moments; and that, when the current has become constant, steady streams of bubbles of gas ascend through the liquid from the surfaces of the electrodes, and from them only. These are some of the characteristics peculiar to electrolytic conduction; and, when present, any one of them is sufficient to distinguish an electrolyte from a simple conductor. We shall discuss them more fully in order.

(1) Exactly as one Daniell cell cannot decompose one electrolytic cell of dilute acid, so two Daniell cells cannot decompose two electrolytic cells. Take, for example, a trough filled with dilute acid, and forming with its platinum electrodes one long electrolytic cell, C, which is traversed by a current from two Daniell cells, B. A distinct deflection will be observed on the galvanometer, G, and the ions will be given off at the electrodes. Now, let a platinum plate, P (shown dotted in fig. 25), of exactly the breadth of the trough be inserted somewhere between the electrodes, and pushed down till it comes into close contact with the bottom of the cell. Very soon the current will die away, or only a very feeble one will remain, which Von Helmholtz has shown to be due to the presence of free gases dissolved in the electrolyte. There will, however, be no continuous production of ions at the electrodes, even in cases in which this feeble current has not been eliminated. The reason is simply that by so partitioning an electrolytic cell we really make it into two. To obtain distinct decomposition in these two cells we must use four Daniell cells in series; and then we should observe the ions given off not only at the terminal platinum plates, but on both sides of the partition plate. Thus it appears that the process of electrolysis is not merely a question of current, but also a question of electromotive force.

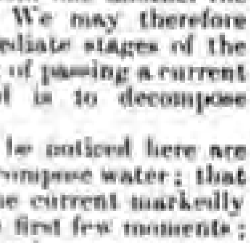


Fig. 25.

(2) To study more closely the second point indicated, take two platinum strips p, q, thoroughly cleaned by heating in a flame to bright redness, dip them into the electrolyte, and connect them to the electrometer. The electrodes being both clean, platinum will have the same contact electromotive force with the electrolyte, so that they will be at the same potential. Hence the electrometer will show zero deflection. Now put the electrolytic cell in circuit with the galvanometer and a battery of two or more Daniell cells; and suppose the current to flow from p to q through the electrolyte. Then it may be observed that, as the current through the galvanometer falls off during the first stages, the difference of potential between p and q as measured on the electrometer increases. If we apply Ohm's Law to the portion between p and q, we see at once that the ratio E/I has considerably increased. This ratio, which for simple conductors measures the resistance, we shall speak of as measuring the Impedance. Impedance in fact is a more general term, synonymous with resistance for steady currents through metals and simple conductors, but including other quite distinguishable properties when electrolytes are the conductors, or when the current is variable. It should be mentioned that during these early changes in current and distribution of potential the temperature of the circuit has not appreciably altered, so that we are precluded from explaining the effect as due to increase of resistance in virtue of rise of temperature.

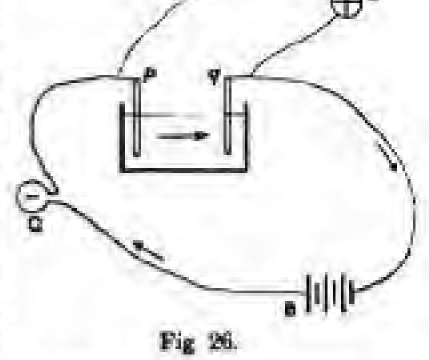


Fig 26.

After the current has become steady, let the circuit be broken. The galvanometer needle will swing back to zero; but the electrometer needle will swing back only a certain distance, and then continue slowly and more slowly back towards zero. Thus, after the current from the battery has ceased to flow, the electrodes in the electrolytic cell remain at different potentials, and will remain so for an indefinite period. This phenomenon is called the Polarisation of the Electrodes. From being in a state of electrical identity these electrodes have been brought, simply through the agency of a current, into a condition of electrical dissimilarity. In other words, the electrolytic cell has virtually become a voltaic cell; the electrodes have become poles at different potentials.

Let now the polarised cell be joined up in circuit with the galvanometer—i.e. let a wire be set in where the battery at first was. The electrode p being at a higher potential than the electrode q, a current will flow from p to q through the galvanometer, and from q to p through the cell—i.e. in a direction contrary to the direction of the current which first circulated in the circuit. As this current flows, the deflection on the electrometer will rapidly fall off, until very soon the potentials of p and q will be practically equalised, and the current will disappear. Thus although, because of the polarisation of the electrodes, the electrolytic cell has at first all the virtue of a voltaic cell, this virtue is rapidly lost when it is used as a source of current, for there is nothing to sustain it.

In this polarisation of the electrodes we have one explanation of the increased impedance of the cell. As soon as the current from an external source begins to pass through, decomposition begins in the electrolyte. The ions accumulate on the platinum electrodes, which become coated with oxygen and hydrogen gases. They are no longer platinum, platinum, dipping in an electrolyte; but oxygenised platinum, hydrogenised platinum, dipping in the same. Of these the latter is eminently oxidisable, just as the zinc is in, say, a simple platinum zinc voltaic cell. Hence the hydrogenised platinum, which is that by which the original current left the electrolyte (q in fig. 26), behaves like the zinc in an ordinary cell, but behaves like the zinc only so long as it is hydrogenised. When, then, the polarised electrolytic cell is included in a circuit otherwise free of electromotive force, a short-lived current will flow at the expense of the electromotive force of polarisation, its energy being derived from the reunion with their appropriate associates in the water molecule of the oxygen and hydrogen clinging to the platinum electrodes. We may express the result very simply in symbols, thus: Let E be the electromotive force acting round the circuit, r the resistance of the electrolytic cell *when there is no polarisation*, s the resistance of the rest of the circuit (galvanometer, battery, and connections). Then if I be the initial value of the current before polarisation sets in, we have, by Ohm's Law,

$$I(r + s) = E.$$

But at once polarisation begins, and the reversed electromotive force due to it more or less quickly attains its maximum value e. If J is the final value of the current, we have, by Ohm's Law,

$$J(r + s) = E - e,$$

in which E and r are supposed to be the same as before. Evidently J is less than I. Again, if we write the quantity e in the form Jk, where k measures something of the nature of resistance, we may at once transform the equation thus:

$$J(k + r + s) = E.$$

The quantity $(k + r)$ measures the impedance.

The unavoidable production of this reversed electromotive force due to the polarisation of the electrodes is a great hindrance in the way of measuring the true resistance of electrolytes. If we put an electrolytic cell into one arm of a Wheatstone bridge, and operate as we do in the case of simple conductors, we should measure the impedance, not the resistance. Suppose, however, that we have in some thoroughly satisfactory manner measured the true resistance, which perhaps might be best defined by Joule's Law in terms of the heating effect of a given current in a portion of the electrolyte far removed from the electrodes, even then we should be in doubt as to the true significance of the rest of the so-called impedance. We see that the electromotive force of polarisation explains a part; but does it explain all? Its existence depends on the accumulation of the ions at the electrodes, and it is quite conceivable that the existence of such accumulations may mean an extra resistance in the true sense of the word.

(3) We pass now to the consideration of the ions themselves. As we have seen, the electrolysis of dilute sulphuric acid results in the appearance at the electrodes of oxygen and hydrogen. The oxygen is given off where the current enters the electrolyte, and the hydrogen is given off where the current leaves the electrolyte. A very simple experiment will show that the amount of water decomposed in a given time is proportional to the current as measured on the galvanometer. Suppose, for instance, that with two Daniell cells in the circuit, the test-tube over the negative electrode in the electrolyte fills with hydrogen in 20 minutes. Then, if four Daniell cells are put in circuit, and the external resistances slightly adjusted so as to make the galvanometer indicate double the former current, the test-tube will be filled with hydrogen in 10 minutes. With six cells, and three times the original current, the tube will be filled in 6⅔ minutes, and so on. Thus we may compare currents by the quantities of a given electrolyte which they decompose in a given time. Faraday's voltameter, as shown in fig. 27, is intended for this purpose. As compared with a galvanometer, the voltameter has the obvious disadvantage that it cannot measure a current at once, but only after the current has been flowing for some time. Hence it measures only the average current during this time; so that unless we know the current to be very constant we cannot draw sure conclusions from the indications of the voltameter. Then, again, there are other sources of error which must be guarded against if anything like accurate results are desired. Thus, in Faraday's voltameter, the gases, as they collect in the test-tubes, are at somewhat diminished pressures in the early stages, so that their volumes do not grow quite proportionately with their masses. But a greater source of error lies in the fact that all the gas given off does not collect in the tubes. Some remains dissolved in the fluid, and this is specially true of the oxygen, which, besides, comes off partly in the denser form of ozone; and some (as the phenomenon of polarisation shows) remains clinging to the electrodes. For ordinary purposes, however, the volume of hydrogen given off in a given tube is a fairly accurate measure of the current effecting the decomposition, and may be used for gauging galvanometers—i.e. for finding what deflection corresponds to the chosen unit of current. For that purpose we must know how much water a unit current can decompose. Now, as proved by Faraday, equal currents decompose equal quantities of a given electrolyte in equal times—i.e. wherever and whenever one milligramme of water is decomposed in one minute by a particular current, that current has a definite absolute value. The numerical measure of it will depend of course on the particular units of length, time, and mass which are adopted as the fundamental units (see UNITS). It is evident, then, that electrolysis gives us a means of measuring a current in terms of a quantity of matter decomposed. To obtain absolute measurements of currents with a galvanometer we require to know the magnetic field in which the galvanometer needle hangs, and the dimensions and arrangement of the coils of wire constituting the galvanometer; but for absolute measurements of currents by means of electrolysis we have to do only with measurements of mass.

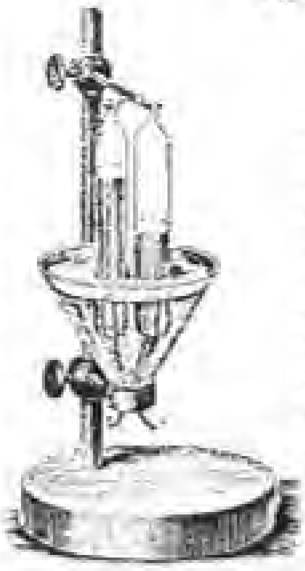


Fig. 27.

Now, not only is the amount of any electrolyte decomposed proportional to the strength of current used, but the amounts of different electrolytes decomposed by the same current have a definite numerical relation to one another—a relation which Faraday showed to have a most essential connection with the known laws of chemical combination.

Let us take, for example, three electrolytic cells—the first, an ordinary voltameter with dilute sulphuric acid as electrolyte; the second, a V-shaped tube containing fused silver chloride with a silver wire for negative electrode and a piece of carbon for positive electrode; and the third, a solution of sulphate of copper with copper electrodes. Let these electrolytic cells be put in series, and a sufficiently strong current passed through them. In the first—the voltameter—oxygen and hydrogen will collect; in the second, chlorine will appear at the carbon, and may be collected, while silver will be deposited on the silver wire; and in the third, copper will be deposited on the negative electrode, while the positive electrode will gradually dissolve away. After the current has flowed for some time, measure the amounts of gases collected, and the amounts of silver and copper deposited. The last two are easily measured by simply weighing the electrodes before and after the process—the increments of mass of the silver and copper which acted as the negative electrodes in the silver and copper salts respectively giving at once the amounts deposited on them. Suppose, for example, that 2 milligrammes of hydrogen and 16 milligrammes of oxygen have collected in the voltameter; then it will be found that 70·8 milligrammes of chlorine have collected over and on the carbon, 216 milligrammes of silver have been deposited on the silver, and 63 milligrammes of copper on the copper electrode. Now these numbers measure what are called the chemical equivalents of these substances—they are proportional to the quantities which enter into similar combinations. Thus, in hydrochloric acid, for every 2 grammes of hydrogen there are 70·8 grammes of chlorine; in cupric chloride, for every 70·8 grammes of chlorine there are 63 grammes of copper; and so on, right through all the related compounds of these substances. See ATOMIC THEORY.

Maxwell has thrown Faraday's fundamental laws of electrolysis into a suggestive form by first defining the electro-chemical equivalent of a substance as that quantity 'which is electrolysed by a unit of current passing through the substance for a unit of time, or, in other words, by the passage of a unit of electricity.' Then the law of electrolysis is that 'the number of electro-chemical equivalents of an electrolyte which are decomposed by the passage of an electric current during a given time is equal to the number of units of electricity which are transferred by the current in the same time.' Now during electrolysis the products of decomposition appear only at the electrodes, and nowhere else. The electrolyte consists in fact of two groups of components, chemically bound together everywhere throughout the liquid. But the steady appearance of the ions at the electrodes shows that the two groups of components must be steadily travelling in opposite directions through the electrolyte. Hence it follows that although these molecular groups are chemically bound together everywhere throughout the liquid, the individual component groups are constantly changing their associates. For example, in the case of the electrolysis of fused silver chloride any individual silver molecule is handed on, so to speak, from chlorine molecule to chlorine molecule till it reaches the negative electrode and is deposited there. At the same time, each individual chlorine molecule passes in the other direction from union with one silver molecule to union with the next, until finally it reaches the positive electrode and becomes free—i.e. there is constant dissociation and recombination going on in the substance of the electrolyte. Clausius (1857) supposes that this process is going on in the liquid at all times; but that, when an electromotive force acts upon it, a direction of motion is given to the component molecules in their momentarily free condition, so that they drift, the one set of components with the electric current, the other set against it. The feeblest electromotive force is sufficient to compel a certain drift of ions, which we may suppose to be conveying the current of electricity by a kind of convection through the liquid. When the ions reach the electrodes, they no longer find ions of the opposite kind to combine with, and begin to accumulate on the electrodes. But for this a finite electromotive force is necessary; for with the accumulation of ions on the electrodes a reversed electromotive force—the so-called electromotive force of polarisation—begins to show itself. This grows with the accumulation of the ions up to a certain point; and if the external electromotive force is not greater than the electromotive force of polarisation so produced, the current will cease to flow, or at least be so enfeebled as to be practically useless in causing electrolysis.

The ions, as they appear at the electrodes, may not be the real components of the electrolyte which are being urged in opposite directions through the liquid. In the case of fused silver chloride, the ions are no doubt these very components; but, in the case of dilute sulphuric acid, we have no right to regard hydrogen and oxygen as the real original products of electrolysis. Indeed, we know by experiment that the purer the water the greater its resistance; so that we have every reason to believe that absolutely pure water is a non-conductor and cannot be electrolysed. Probably the secondary actions which in the case of dilute acid transform the real original ions into oxygen and hydrogen may be somewhat similar to what is certainly part of the action when a solution of sulphate of soda is electrolysed. The components of the molecule Na_2SO_4 are Na_2 and SO_4—i.e. sodium and what is called sulphion. The sodium molecules drift with the current, the sulphion molecules against it. But the sodium, when it appears at the negative electrode, at once acts chemically on the water, forming soda, Na_2O, and liberating hydrogen, H_2. Again at the positive electrode, the sulphion not being able to exist in the free state, breaks up into SO_3 and O; and then the sulphuric acid is dissolved up in the water, and oxygen is given off. Thus, again, the constituents of water, H_2O, appear as the ions, exactly as in the case of the dilute acid. Here, however, the molecule of the electrolyte is not really Na_2SO_4, but has so much water united with it. Thus there may be a direct decomposition of water, as well as of the sulphate of soda. Whatever the real process of electrolysis, it is certain that in many cases secondary chemical actions quite mask it. These secondary actions do not, however, affect the accuracy of the law of electrolysis. Whatever be the apparent products of decomposition, these, if they can be caught and measured, will appear in quantities proportional to their chemical equivalents. It is further evident that if one electro-chemical equivalent of an electrolyte is decomposed, it must be decomposed into components chemically equivalent to one another and to it.

Hence it is enough to measure carefully the electro-chemical equivalent of one of the ions or products of decomposition. By means of a table of chemical equivalents we shall then be able to calculate the electro-chemical equivalents of given electrolytes. So many are the causes, both physical and chemical, which tend to disturb the perfect accumulation of the ions on or over the electrodes, that the accurate experimental determination of the electro-chemical equivalent is a matter of great difficulty. Large copper electrodes in copper sulphate yield fairly good results; but the only completely satisfactory combination is a particular solution of nitrate of silver with pure silver electrodes. The electrolysis of this electrolyte by means of a current, whose strength should be adjusted to the size of the electrodes, so as to give a particular amount of current per unit area, is accompanied by an accurate transference of so much silver from one electrode to the other. In other words, the one electrode loses as much as the other gains, a degree of perfection which is hardly ever attained in other cases. Recent independent determinations by Kohlrausch and Rayleigh agree to the fourth significant figure; so that we may safely say that the unit of current known as the ampère will reduce out of a solution of nitrate of silver 1·118 milligrammes of silver per second. This therefore is the electro-chemical equivalent of silver. Now in chemical combinations 216 grammes of silver correspond to 18 grammes of water and to 65 grammes of zinc. Hence a simple calculation gives ·0932 milligrammes as the electro-chemical equivalent of water, and ·336 milligrammes as the electro-chemical equivalent of zinc.

The unit of current which has just been mentioned, the ampère namely, is one-tenth of the electro-magnetic unit of current, which may be defined in several ways (see MAGNETISM). For our present purpose, however, it will be sufficient to indicate experimentally what magnitude of current the ampère is. If an ampère is passing along a conductor of 1 ohm resistance—say, a column of mercury 106 centimetres long and 1 square millimetre cross-section—the electromotive force along the conductor—i.e. the difference of potential of its ends—will be the quantity known as 1 volt; and the volt is such that the electromotive force of a Daniell cell is about 1·08 volts. In connection with electric lighting, these units—the volt, the ampère, and the ohm—are in universal use.

Intimately connected with electrolysis is the theory of action of the ordinary galvanic or voltaic cell. For, whenever such cells are being used for the production of electric currents, there is going on within them chemical actions essentially electrolytic. Take, for example, the Daniell cell with its copper and zinc plates dipping respectively in solutions of copper and zinc sulphates. When the cell is closed, the current flows externally from the copper to the zinc, and internally from the zinc through the zinc and copper sulphates to the copper. The electrolysis of these electrolytes is a necessity, with the result that the zinc is gradually dissolved away, and copper deposited on the copper electrode. The net chemical result is the removal of copper from the sulphate and the substitution of an equivalent of zinc. But this chemical reaction is accompanied by the evolution of heat—i.e. the liberation of so much energy available for transformations. It is this energy which is the source of the electric energy when the replacement of copper by zinc in the sulphate is effected in the particular arrangement known as the Daniell cell. Now, according to Thomson's determinations of heats of combination, the consumption of 1 gramme of zinc in a Daniell cell means the evolution of 8053 gramme-degrees, that is, an amount of heat that would raise 8053 grammes of water 1° C. in temperature. Hence the consumption of an electro-chemical equivalent of zinc—i.e. ·336 milligrammes—means the evolution of 2·706 gramme-degrees of heat. This then is the energy which is associated with the production of one unit of electricity. To reduce it to dynamic units we must multiply by the factor $4·2 \times 10^7$, which is the number of units of energy equivalent to the heat required to raise the temperature of 1 gramme of water 1° C. Thus we find $1·14 \times 10^8$ as the energy which a Daniell cell liberates per second when it produces a current of 1 ampère. If E is the electromotive force associated with this unit current, then E measures the work done per second by the current; and assuming that this is the energy liberated in the cell, we find $E = 1·14 \times 10^8$ electro-magnetic (C. G. S.) units of electromotive force—i.e. 1·14 volts, according to the definition of a volt. This is slightly higher than the real value of the electromotive force of a Daniell cell, but it is close enough to warrant the conclusion, first enunciated by Sir William Thomson (1851), that the electromotive force of any electro-chemical apparatus is, in absolute measure, equal to the dynamical equivalent of the chemical action that takes place during the passage of unit current for unit time. There are many cases of galvanic combinations for which this principle fails to a degree which cannot be even approximately referred to errors of experiment. Some other principles, either chemical or physical, must be involved. There is no question, however, as to the general application of the law enunciated by Thomson.*

We are now able to see why it is that one Daniell cell cannot effect an electrolysis in which the constituents of water appear as the ions. It is simply because the heat developed in the formation of an equivalent of water by direct union of its constituents is about half as great again as the heat evolved in the combustion of an equivalent of zinc in a Daniell cell. Hence to decompose an electro-chemical equivalent of water requires more energy than is supplied by the combustion of an electro-chemical equivalent of zinc in the cell.

The general principle here indicated may be stated thus: A current i flowing through a given electrolyte decomposes i electro-chemical equivalents in unit time. But this requires a definite amount of work done, which we may write ie, where e measures the work which must be done to decompose one electro-chemical equivalent. Hence the energy of the current must be *at least* ei, or in other words, e measures in absolute measure the smallest electromotive force with which distinct electrolysis can be effected.

All the phenomena which accompany simple electrolysis are encountered in the action of galvanic cells. The poles, like the electrodes, become, or tend to become, polarised. This is especially the case in single fluid cells, in which the apparent electromotive force very markedly diminishes during the first few moments of action, due to the reversed electromotive force of polarisation produced by the accumulation of the ions on the poles. In the so-called constant elements, such as the Daniell, the Bunsen, or the Grove, all of which are double-fluid cells, the ion is either of the same nature as the pole at which it appears, or is dissolved in the fluid so as not to accumulate. By such means the electromotive force is kept fairly constant so long as the strengths or characters of the solutions do not greatly alter. The chief conditions to be fulfilled by cells which are to yield strong steady currents are (1) small polarisation, (2) a plentiful supply of electrolyte, (3) a small resistance. This last condition is obtained by using large surfaces for the electrodes, which are opposed to each other as closely as the arrangements of the cell will permit.

The difficulties of measuring the true resistance of electrolytes, and therefore of galvanic cells, have already been touched upon. We must here confine ourselves to the chief results which experiment has established. As compared with metallic conductors, the specific resistance of electrolytes is very great. Then, again, rise of temperature diminishes the resistance of electrolytes, whereas, except for selenium, phosphorus, and carbon, it increases the resistance of simple conductors. Finally, in the case of solutions in water of such compounds as sulphuric acid, nitric acid, sulphates, chlorides, nitrates, and so on, there is in general a definite solution which conducts better than any other solution of the same substance—i.e. a definite percentage composition which is associated with a minimum specific resistance. In all cases a condition of infinite resistance is approximated to as the solution is taken weaker and weaker; and in some instances (sulphuric acid, for example) the same condition of infinite resistance is hinted at for infinitely strong solutions—i.e. for the pure non-hydrated substance. Kohlrausch, who has probably worked most extensively at this subject, speculates upon the necessity of solution or of mixture of stable chemical compounds before conduction can take place. In other words, such compounds, if absolutely pure, would be non-conductors.

We cannot hope to understand the true nature of resistance till we know what an electric current really is. The fact that electrolytes obey Ohm's Law as accurately as simple conductors suggests that the process of conduction is essentially the same in both, notwithstanding the many differences that exist in the accompanying phenomena. The view that an electric current is intermittent—i.e. is a succession of distinct discharges at extremely short intervals of time, is one which seems to be involved in all the best theories of electrolysis that have been elaborated. Maxwell has shown that a rapid intermittent charging and discharging can give rise to all the effects of a true resistance. Suppose we have a condenser of capacity C, whose plates are, by means of a tuning-fork interrupter, alternately brought into contact with the poles of a battery and with each other, so that the condenser is charged and discharged n times a second. If E is the electromotive force of the battery, EC is the electricity which passes at each discharge. Hence in one second ECn units of electricity pass; and this is the current I. Thus

$$I = ECn,$$

so that Cn measures the conductivity. The greater n is, the greater the conductivity, the less the resistance. Hence, if the electric current is of the nature of intermolecular discharge, we see that greater closeness of the molecules, being in all probability associated with more rapid charging and discharging, will give rise to less resistance. This would so far explain the much greater resistance of electrolytes as compared with metallic conductors. For a very complete statement of this view, consult Professor J. J. Thomson's *Applications of Dynamics to Physics and Chemistry* (1888).

The hypothesis just given of the intermittent character of electric conduction obviously suggests that the mode by which electric transference takes place in simple conductors, electrolytes, and dielectrics is fundamentally the same. In many dielectrics the phenomenon of 'leakage'—the name given to the gradual loss in charge of a conductor in contact with the dielectric—presents characteristics very similar to true ohmic conduction. Then dry glass, although a very good insulator at ordinary temperatures, becomes distinctly conducting at temperatures above 200° C.—a fact first noticed by Cavendish. Later experiments indicate that the conduction of hot glass is electrolytic, the electrodes becoming polarised. In the case of gases, electrical discharge seems always to be of an intermittent character. A certain electromotive force, depending on the shape and size of the electrodes, on their distance apart, and on the density, temperature, and nature of the gas, is necessary before discharge takes place. For smaller electromotive forces, the gas, if free from convection currents, seems to insulate perfectly. The insulating power of the gas under given conditions is measured by its dielectric strength, which varies as the square of the electric force. The dielectric strength increases markedly for very small distances between the electrodes, a very remarkable fact which may possibly be due to a greater density of gas close to the surfaces of the electrodes. For smaller and smaller distances such condensed layers would of course play a more pronounced rôle. This explanation agrees with the fact that the dielectric strength of gases diminishes as the density is diminished. This, however, does not go on indefinitely, but it reaches a minimum for a certain low density, which has a different value for each gas, and which is also a function of the diameter of the tube in which the rarefied gas is contained. A pressure of 2 or 3 millimetres of mercury gives the density for which the dielectric strength of air reaches its minimum. Further rarefaction beyond the point of minimum dielectric strength is accompanied by a rapid increase of insulating power, until at length it is impossible to make a discharge pass through the extremely attenuated gas. It thus appears that electricity cannot pass from electrode to electrode in a perfect vacuum—i.e. a region void of ordinary matter. Whether this is due to an infinite passage resistance between the electrodes and the so-called vacuum, or to the absolute non-conducting power of the vacuum, is a point not yet settled. Electric discharge through rarefied gases is accompanied by very beautiful luminous effects, which are often enhanced by the phosphorescence of the glass forming the vacuum tubes. These tubes are usually called Geissler tubes, after

the first great maker of them (the glass-blower and mechanician, Heinrich Geissler, 1814-79). Into their many curious properties we cannot here enter.

The polarisation of the electrodes during electrolysis has within the last ten years acquired a great practical importance in connection with the construction of secondary batteries or accumulators. An accumulator is simply a polarised electrolytic cell capable of supplying a steady current for a lengthened time. Theoretically of course, all polarised electrolytic cells are accumulators; but usually the currents they supply are short-lived and feeble. It was not till 1860 that Planté constructed an accumulator which could supply a really efficient current. The Planté secondary cell is formed by the electrolysis of dilute acid with lead electrodes. With sufficiently strong currents, the result of the electrolysis is that the positive electrode becomes covered with peroxide of lead (PbO_2), while lead accumulates in a spongy form on the negative electrode. When the polarisation has been carried on to a sufficient extent, the cell is said to be charged, and it will be found to have all the properties of a true galvanic cell of low resistance and fairly high electromotive force (about 2 volts). On being closed, it will supply a current sufficient to keep a thin wire glowing for several hours. At the same time, the peroxide of lead will become reduced to a lower oxide, and the spongy lead will be oxidised, while the sulphuric acid present gives rise to other reactions. During the greater part of the discharge of the cell, the electromotive force remains very constant, and only begins to diminish as the depolarisation approaches completion. When the charged cell has thus, through use, lost nearly all its accumulated electrical energy, it is put into circuit with a primary source of current energy and re-charged. The modifications of construction introduced by Faure in 1881 gave a great impulse to the development of accumulators as a practical source of electrical energy. Instead of using merely lead sheets as electrodes, Faure covers them first with a layer of minium or red lead. With these as electrodes the electrolysis of dilute sulphuric acid is effected, the result being, as before, the formation of peroxide of lead at the positive electrode and spongy lead at the negative electrode. What chemical reactions take place as the accumulator discharges itself are not fully understood. The final result, however, seems to be the formation of sulphate of lead on both electrodes. Re-charging from a prime source restores the peroxide of lead and the spongy lead as in the first charging. As part of the recent development in electric lighting, the efficiency of accumulators has been greatly increased; and they are now largely used as the direct source of power. They must, of course, be charged and re-charged at intervals depending upon the particular rate at which they are made to give off their stored-up energy. A battery of Bunsen or other cells may be used for charging purposes; but if the wasteful voltaic cell had been our only prime source of electric energy, the secondary cell could never have assumed the practical importance it has. It is because we can generate electric energy dynamically and economically (see MAGNETISM) that we find a use for the accumulator, which is simply an arrangement for the storage of so much electrical energy in a form convenient for future purposes.

Of all the thermal effects produced by currents, the Joule Effect is the most conspicuous and by far the most important. But there are other thermal effects which are associated with the transference of electricity, and which are readily distinguished from the Joule effect by what is known as their reversible character. Thus the Joule effect always means a rise of temperature in the conductor whatever the direction of the current through it; whereas these so-called reversible effects mean a rise of temperature when the current passes in the one direction, and a fall when it passes in the other. If at any part of a circuit, in which a current is flowing, a fall of temperature is observed, we are probably safe in regarding this cooling effect as one of these reversible effects. We may test this directly by reversing the current; but occasionally the conditions of the experiment may prevent the application of this test. Thus, in some cases, a galvanic cell, in circuit with a large external resistance, is found to cool. Since the current due to a given galvanic combination must always flow in the same direction through the cell, it is impossible of course to apply the test of reversal. Other galvanic cells, again, when similarly joined up with a high external resistance, are found to rise in temperature under conditions in which the true Joule effect is inappreciable. Such thermal effects seem to be true reversible effects; and upon them Von Helmholtz bases his explanation of the apparent failure, in many instances, of Thomson's dynamical theory of the electromotive force of a battery (see above). In most cases, the electromotive force is smaller than what the chemical reactions imply; but in some it is greater. In the former there is intrinsic heating in the cell; in the latter there is cooling—exactly the relations which the principles of energy require. For, as in the latter case, if the electrical energy generated is greater than the *chemical* energy supplied, it must borrow heat from the surrounding substances to make up its surplus energy. The further fact that those cells, which either heat or cool of themselves, have electromotive forces which vary with temperature, points to these being truly reversible thermal effects. An electromotive force which grows with temperature is associated with a cooling effect in the cell as the current is flowing, while an electromotive force which diminishes with rise of temperature is associated with a heating effect. This must be so; for in all cases of transformations of energy, the final effects react so as to resist the changes that lead to them. In the present case, if a heating effect co-existed with an electromotive force which increased with temperature, this heating effect would raise the temperature still further, increase the electromotive force still more, and cause a stronger current to flow, which in its turn would cause a further rise of temperature, and so on indefinitely—an obvious contradiction of all experience. We shall find some simple applications of the same dynamic principle of reaction in the other reversible thermal effects of electric currents. These are intimately connected with the whole subject of thermo-electricity, which we shall now discuss.

Thermo-electricity dates from 1821, when Seebeck discovered that a current was generated in a circuit composed of copper and antimony, when the junctions were at different temperatures. With a **sufficiently delicate galvanometer, the same phenomenon may be shown not only with any two different metals, but also with the same metal in two different conditions. Thus, a stretched, twisted, or (if possible) magnetised wire will give thermo-electric currents with a piece of the same wire which has not been so treated. Slight** impurities cause distinct changes in thermo-electric properties; indeed, thermo-electric currents may often be obtained in a circuit of two wires, which no other physical test can differentiate. The fundamental fact of thermo-electricity is that, in a circuit built of two or more different conductors, a current is in general generated when one junction at least differs in temperature from the others. For the sake of definiteness, consider a circuit of the two metals iron and copper, with their junctions at A and B, and with a delicate galvanometer included for the measurement of current. If A and B are at different temperatures, a current will in general be set up in the circuit; and for moderate temperatures up to 250° C. or so, this current will flow from copper to iron through the warmer junction, and from iron to copper through the colder junction. Now this current i must derive its energy, ei, from some source; and the only source that exists is the heat which is available in virtue of the unequal distribution of temperature. In virtue of thermal conduction and radiation, the tendency is towards an equalisation of temperature, the warmer junction losing heat, and perhaps the colder junction gaining heat. But if this heat is also being partly drawn upon to sustain an electric current, the equalisation of temperature will be hastened because of this transformation into electric energy. Hence, we should expect the thermo-electric current to be associated with, at anyrate, a cooling effect at the warmer junction. That such an effect really does exist was established experimentally in 1834 by Peltier—hence the name Peltier Effect. He showed that heat is absorbed or evolved at the junction of two different metals, across which any current is made to pass; and that if the direction of this current is the same as that of the thermo-electric current that would be produced by heating the junction, the effect is absorption of heat—i.e. cooling; and *vice versâ*. Thus, in a copper-iron circuit at moderate temperatures, the thermo-electric current is associated with a cooling effect at the warmer junction, and a heating effect at the colder junction. Icilius proved by experiment (1853) that the Peltier effect is proportional to the strength of the current. It is also known to vary with the temperature, sometimes increasing with rise of temperature, sometimes diminishing, according to the particular kinds of metals used.

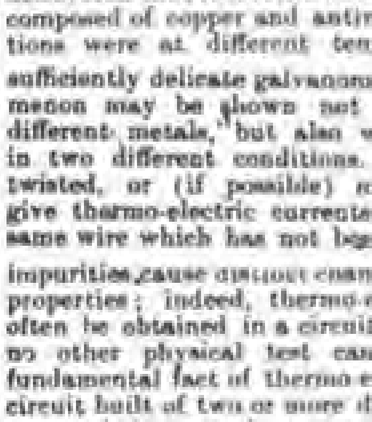


Fig. 28

The Peltier effect is defined as the heat absorbed by the passage of unit of electricity in the proper direction across the junction; or otherwise, the heat absorbed per second by the passage of unit current. Let p be the Peltier effect at the warmer junction of a thermo-electric circuit, and p' its value at the other junction. Assuming that the Joule and Peltier effects are the only thermal accompaniments of a thermo-electric current i, we find for the whole amount of heat absorbed the quantity pi, and for the whole amount of heat evolved $p'i + ri^2$, where r is the resistance of the circuit, and where the heats are estimated in dynamic units. If we suppose these to be the only transformations of energy involved, we have at once

$$pi = p'i + ri^2 \text{ or } p - p' = ri.$$

In the latter equation, the difference of the Peltier effects appears as the electromotive force **associated** with the current i. From this point of view the Peltier effect is to be regarded as an abrupt change of potential at the junction of the two metals. It must not be confused, however, with the electromotive force of contact discovered by Volta, compared with which it is extremely small, and frequently of opposite sign.

Thus we may suppose thermo-electric currents to be explained in terms of the Peltier effects, regarded as electromotive forces at the junctions. But the striking phenomenon of thermo-electric inversion, discovered by Cumming in 1823, necessitates the supposition of other than Peltier effects for a satisfactory explanation of thermo-electric currents. Take, for example, the copper-iron circuit, keep the one junction B at a steady temperature of, say, 10° C., and raise the temperature of the other junction A steadily and indefinitely from 10° C. to about a dull red heat. As the temperature of A rises, the current setting from copper to iron through A will increase to a maximum, then decrease to zero, and finally become reversed. The temperature at which this maximum current is obtained is a definite temperature for a given pair of metals, being quite independent of the temperature of the other junction. It is called the Neutral Point. If the temperature of the one junction is as much above the neutral temperature as the temperature of the other junction is below it, there is no current; and the mean of these two temperatures is the neutral temperature. For copper-iron the neutral point is about 275° C.; for zinc-iron, about 210° C.; for cadmium-iron, about 160° C.; and so on. In the majority of cases, the neutral point, occurring either above or below ordinary ranges of temperature, cannot be easily observed directly; but its position is usually indicated by the manner in which the electromotive force is found to vary with temperature. Now suppose that the one junction A in the copper-iron circuit is kept at the neutral temperature (275° say); then whatever be the temperature of the other junction, whether it is higher or lower than 275°, the direction of the current will always be the same—viz. from copper to iron through the junction A. Consider the two cases: (1) B at temperature 270°; (2) B at temperature 280°. In the first case, if the only reversible thermal effects existing are the Peltier effects at the junctions, then there must be absorption of heat at A (copper to iron), and (if anything) evolution of heat at B (iron to copper).

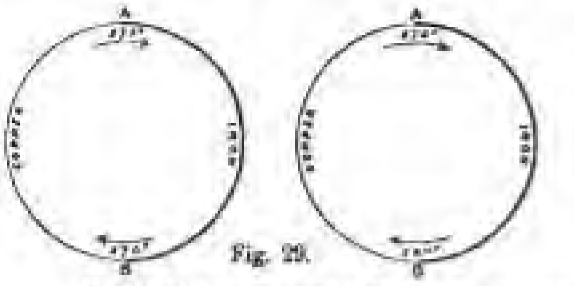


Fig. 29.

But in the second case, the same assumption requires that there must be absorption of heat at B (iron to copper), and (if anything) evolution of heat at A (copper to iron). Now these two statements are incompatible unless there be neither absorption nor evolution of heat at A—i.e. unless the Peltier effect vanish at the neutral point. But this being so, it is at once evident that in the first case there is no absorption of heat at all. Heat is evolved at B, and heat is evolved because of the Joule effect; but there is no evidence of any absorption of heat to account for the energy of the current. Hence the original assumption must be wrong—i.e. there must be other reversible effects in the circuit besides the Peltier effects at the junctions. There must be a cooling effect either in the copper wire, or in the iron wire, or possibly in both. This theoretical conclusion was first obtained by Sir William Thomson (1851), who proceeded at once to test it by an appeal to experiment. It was found that both of these predicted effects take place. A current passing from cold to hot in copper is associated with an absorption of heat; while heat is evolved if the current passes from hot to cold. On the other hand, for iron, things are just reversed; cooling is associated with the current that flows from hot to cold, and heating with the current that flows from cold to hot. This reversible thermal effect which accompanies the passage of a current in an unequally heated conductor is called the Thomson Effect. It is said to be positive in copper; and is therefore negative in iron. Cadmium, zinc, silver, gold, nickel between the temperatures of 250° C. and 310° C., and iron above a dull red heat, have, according to Professor Tait's experiments, their Thomson effects also positive. Platinum, palladium, potassium, sodium, cobalt, nickel below 200° and above 320°, and probably iron again above a bright red heat, are examples of metals having negative Thomson effects. The Thomson effect has been measured directly in a very few cases; but it may be calculated from thermo-electric constants, if Tait's hypothesis be true (and recent direct experiments go far to verify it) that the Thomson effect is for most metals directly as the mean absolute temperature. The extraordinary change of sign in the Thomson effect, which Tait discovered to exist both in nickel and iron at certain temperatures, is an extremely interesting phenomenon, and seems to be connected with other properties peculiar to these magnetic metals—such as their loss of magnetic susceptibility and the manner in which their electrical resistances change with temperature.

In comparison with the electromotive forces of voltaic cells, the electromotive forces that can be obtained with thermo-electric circuits are usually very small. Thus copper-iron with one junction at 275° C., and the other at 0° C., has an electromotive force of only ·0022 volts. The electromotive force of an iron-nickel pair with junctions at temperatures 0° C. and 200° C. is ·008 volts; and the electromotive force of a bismuth-antimony pair with a difference of temperature of 50° C. is about ·005 volts. Bismuth and antimony are, because of their high mutual thermo-electromotive force, ordinarily employed in the construction of the thermopile, a valuable instrument for indicating and measuring small variations of temperature. It consists of alternate strips of bismuth and antimony forming a continuous zigzag chain, as indicated in fig. 30. They are arranged in compact form so that the successive junctions alternate, now on this side, now on that side, forming two plane faces looking opposite ways. If a source of heat is brought opposite to the one face, the junctions ending there are heated by radiation, while the alternating junctions on the other face remain at the temperature of the air. Each pair of junctions gives rise to a thermo-electromotive force e, and therefore the n pairs to ne. If s is the resistance of each pair of strips, and r the resistance of the galvanometer and connecting wires, the current i is given by the equation

$$i\,(r + ns) = ne.$$

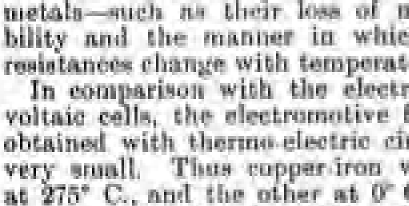


Fig. 30.

Thus i is always greater the greater n is; and if, as is usually the case, the resistance of the thermopile (ns) is small compared with the resistance of the galvanometer, the current due to the n pairs is very nearly n times the current that one pair would give. Thus a thermopile of thirty-six pairs of junctions will give an electromotive of nearly one-tenth of a volt for a difference of temperature between the faces of 25° C.

The Peltier effect between bismuth and antimony at the ordinary temperature of the air is about $3{\cdot}14 \times 10^6$ per ampère per second, estimated in dynamic units—i.e. about ·0075 in gramme-degree units of heat. Hence in one minute, a current of one ampère passing from antimony to bismuth will evolve a quantity of heat sufficient to raise a gramme of water nearly half a degree centigrade in temperature. For other ordinary pairs of metals, the Peltier effect is considerably smaller than that just given. Thus for iron-copper at the ordinary temperature of the air, the Peltier effect is about one-seventh of its value for bismuth and antimony.

The Thomson effects are extremely difficult to measure directly. We may, however, get an idea of their magnitudes by calculating them according to Tait's theory from the thermo-electric constants. Suppose, for example, that a current of ten ampères is flowing along an iron or copper wire, whose ends are at 0° C. and 100° C. Then the amounts of heat in gramme-degrees evolved or absorbed per minute are, in iron ·224, in copper ·044. These numbers are calculated on the assumption that the Thomson effect in lead is nil, an assumption based on the direct experiments of Le Roux.

Electric Light. The electric light, like light from most other sources, is produced by raising a body to a temperature so high that some of the radiations it throws out have a wave-length short enough to affect the retina. A slightly heated body gives radiations of long wave-length only; they may be detected, as any radiations may, by their heating effect when they fall on an absorbent surface, but the eye is not sensitive to them. When the body is made hotter the whole energy of the radiations increases, but the short waves increase in greater proportion than the long waves, and when the temperature is sufficiently raised the body begins to give out light. So long as the source is just hot enough to be luminous the light is nearly all red; as the temperature rises there are added more and more of the other colours, of shorter wave-length, towards the violet end of the spectrum. In the flame of a candle or of a gas-jet particles of solid carbon form the luminous source; their temperature, which is determined by the condition that they radiate energy as fast as work is done upon them by the process of combustion, is so low as to make the red and yellow constituents of the light preponderate. A higher temperature has the double advantage of giving whiter light, and of giving it accompanied by a smaller proportion of non-luminous infra-red rays, and therefore with less expenditure of energy in proportion to the amount of light produced.

One way of heating a body to a high temperature is by forcing a strong current of electricity to pass through it. The energy expended depends on the strength of the current and on the electromotive force which is required to make it pass, and this energy takes the form of heat. By selecting a conductor which offers considerable resistance to the passage of the current, it is practicable to produce so much heat in a small space that the temperature reached is only limited by the melting or volatilising of the heated body. In all actual electric lamps carbon is used, first and mainly because of its great infusibility, and second, because of its emissive power. Carbon is in fact the luminous body in nearly all sources of artificial light.

Arc Lighting.—The earliest means of applying the electrical current to the production of light was discovered in 1810 by Sir Humphry Davy, who found that when the points of two carbon-rods, to which the terminals of a powerful battery were connected, were brought into contact and then drawn a little way apart, the current continued to pass across the gap, forming what is known as the electric arc. The electric arc (fig. 1) is brilliantly luminous. The points of the carbon-rods become highly incandescent, and in addition the space between them is filled by a sort of flame, or cloud of particles of white-hot carbon. As the temperature of the arc is much higher than that of any ordinary flame, its efficiency as a source of light is exceptionally great, and it is specially rich in highly refrangible (or short wave-length) rays. The carbon-points being exposed to the air gradually burn away, and in addition to this there is a transfer of carbon particles across the arc from the positive to the negative rod, which has the effect of making the positive rod waste about twice as fast as the negative rod. The end of the negative rod becomes somewhat pointed, and a crater-like hollow forms on the end of the positive rod. As the points waste away the arc lengthens, and would presently break and the current would cease to pass if the rods were not pushed nearer together. Should the arc break it can be re-established by bringing the rods again into contact, and again drawing them a little way apart. Arc lamps are devices for holding the carbon-rods, so that they are first brought into contact and drawn apart, to establish or 'strike' the arc, and are then 'fed' together, continuously or at short intervals, to prevent the distance between the points from growing too long.

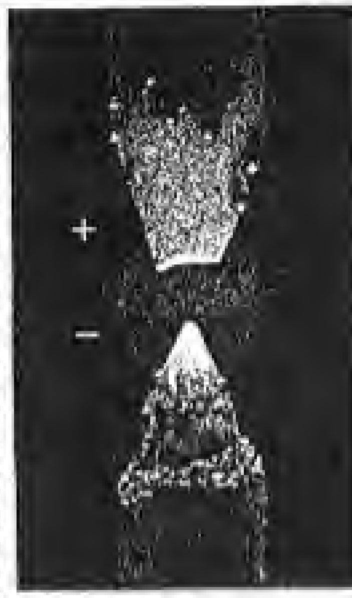


Fig. 1.

It was not until the development of the Dynamo-electric Machine (q.v.) as a means of producing the electric current economically on a large scale, that the electric light came to be of commercial importance. Before that, however, various contrivances had been devised for automatically striking the arc and regulating its length. As early as 1847 a lamp was patented by W. E. Staite, in which the carbon-rods were set vertically one over the other, the upper one being held fixed, while the lower rod was fed upwards by the intermittent action of clockwork, which came into gear whenever the current across the arc became reduced below a certain limit of strength through the lengthening of the distance between the carbon-points. Similar devices were proposed by Foucault and others; but the first really successful arc lamp was Serrin's, patented in 1857, which has not only itself survived, but has had its main features reproduced in many later forms. In 1858 a lamp designed by Duboscq was used to show the electric light, for the first time at sea, from the South Foreland Lighthouse, where the current to feed the lamp was generated by the large magneto-electric machine of Holmes; and this experiment was followed a few years later by the permanent establishment of electric lighting there and at Dungeness and other lighthouses. The invention of the self-exciting dynamo in 1867 paved the way for the development of electric lighting on a commercial scale. The Jablochkoff candle (1876), in which the arc was formed between the ends of a pair of parallel carbon-rods separated by a layer of insulating material which was slowly consumed as the carbon burned down, did good service in accustoming the public to the new illuminant, and the invention of simple and effective arc lamps by Brush and others, brought about its wide adoption in 1878-79 for lighting large rooms, streets, and spaces out of doors. In the following year the future of domestic electric lighting was secured by the introduction of the incandescent lamp.

In modern arc lamps, of which there are so many forms that it would be impossible even to classify them in the space at our disposal, the arc is generally struck by the action of the current in an electro-magnet or solenoid, which is connected in series with the carbons, so that when the current passes the armature of this magnet is attracted, and its motion is caused to separate the carbons. This sets the lamp in action, and then, as the carbon-points are consumed, the resistance to the passage of the current gradually increases. If the source of electricity is such as to maintain a constant, or nearly constant, difference of potential between the terminals of the lamp, the effect will be that the current will gradually become reduced. On the other hand, if the source is such as to maintain a constant or nearly constant current through the lamp, the effect will be that the difference of potential will increase. Either of these effects may be made use of to regulate the length of the arc. Generally the carbons (which are round rods formed by making powdered coke into a paste and baking it) stand in a vertical line, and the upper one is fixed in a heavy holder, which tends to slide down until the points touch. But its motion downwards is checked by a clutch or brake of some kind, which allows it to descend little by little, and only when the length of the arc has become unduly great. Fig. 2 is a skeleton diagram showing the mechanism of Serrin's arc lamp, which was one of the earliest successful forms. Here the upper carbon-holder, A, has rack teeth on it, which gear into the first of a train of toothed wheels, BC, so that the train must revolve as the carbon descends. The last wheel in the train, C (which moves much for a very small movement of the holder), is a star-wheel, whose projecting limbs hit or miss a detent, E, the position of which is controlled by an electro-magnet, G, pulling against a spring, F. When the arc is struck the star-wheel is locked, so that the upper carbon-holder is fixed.

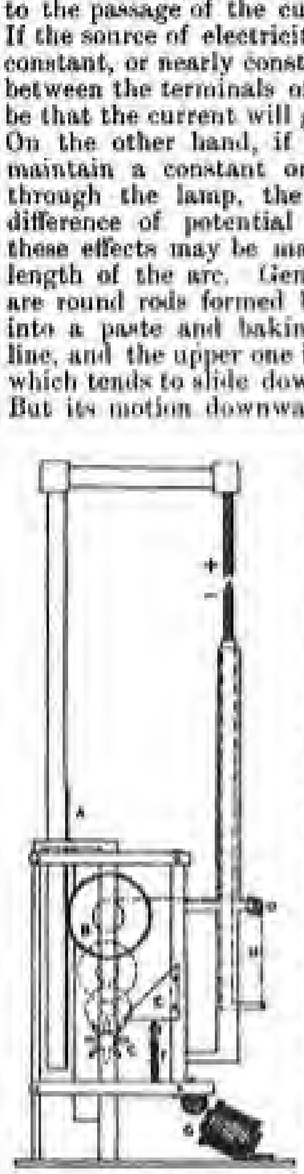


Fig. 2.

As the arc lengthens, the current in the controlling electro-magnet becomes weakened, and this goes on until the detent rises far enough to release the star-wheel. The holder, A, then descends until the current is again strong enough to make the electro-magnet draw the detent down and lock the wheel. Here the control depends on variations in the strength of the current passing across the arc, and the controlling electro-magnet is in series with the carbons (being in fact the magnet which also strikes the arc); if, however, the lamp were to be used with a constant current, the control could easily be effected by variations in the difference of potential between the carbons. The controlling magnet must then form a shunt to the arc itself, and be set so that when the shunt current in it is weak the star-wheel is locked, and when the shunt current exceeds a certain limit the detent is raised and the star-wheel is released. The lamp shown in fig. 2 has this peculiarity, that the descent of the upper carbon-holder makes the lower holder rise, through half the distance, by means of the pulley D, and chain H. The effect is to keep the arc burning always at one and the same place, the lower carbon being the negative one, which consumes half as fast as the other. Lamps with this feature are called 'focussing' lamps, and are useful in lanterns where the luminous centre must be maintained in the focus of a lens. For ordinary uses the focussing arrangement is not necessary, and is omitted.

In many modern lamps the controlling electro-magnet is double, consisting of a series and a shunt portion, combined in such a way that the holder is released, and the carbons are caused to approach by either a weakening of the current or an increase of the potential, or both. Such lamps may be used either with constant current or with constant potential.

In place of the train of wheels in Serrin's lamp, a single brake-wheel has been used, turned by a rack on the upper carbon-holder, and stopped or checked by a brake-lever which is pressed against or withdrawn from its circumference by the controlling electro-magnet. Some very successful modern lamps, such as those of Brush and Thomson-Houston, use a still simpler device. The upper carbon-holder slides through a loose collar or ring, which can be tilted by the controlling magnet, so that it clutches the holder. When the current falls or the potential rises this clutch collar is untilted, so that the holder slips through it and shortens the arc. A dash pot is employed to prevent the fall of the holder from being too rapid.

When a number of arc lamps are to be used together they are generally connected in series; a constant current is sent through the group, and the control of the carbons is effected by shunt electro-magnets, taking advantage of variations in the difference of potential between the carbons. To prevent the whole group from being extinguished should the feeding mechanism in any one lamp fail to act, a device is added by which any lamp that fails is short-circuited—i.e. the current passes through it by another path. They may, however, be grouped in parallel, if the control is arranged to depend on variations in the strength of the current. Parallel grouping is usual when the lamps are to be served with alternating electric currents.

The rate at which energy is expended in the electric arc is measured by the product of the current and the electromotive force required to maintain it passing across the gap. If the current be measured in ampères and the electromotive force in volts, their product gives the rate of expenditure of energy in watts, and may be reduced to horse-power by dividing by 746. It is found that the electromotive force between the points is nearly constant whether much or little current is passing, which shows that the opposition to the passage of the electric current across the gap is different in kind from the resistance of an ordinary conductor. However short the arc be it requires an electromotive force of from 30 to 40 volts to maintain it; when the arc is lengthened the electromotive force necessary to keep up the same current is increased, but not in proportion to the length. It is not found practicable to maintain the arc with less than a certain strength of current. Hence the power consumed in an arc lamp is necessarily considerable, and the lamp can be employed to advantage only where a large amount of light will be serviceable. The arc lamps which are most extensively used take from three-quarters to one horse-power, and have an illuminating effect equivalent to something like 1000 candles. It is impossible to speak with any precision of the candle power of an arc lamp, because its light differs enormously in colour from that of a standard candle. A comparison of the blue rays of the arc with the blue rays of the candle will give a figure nearly three times more favourable to the arc than if the comparison be made between the red rays.

Incandescent Lighting.—In early attempts to produce light by the incandescence of a heated conductor, wire of platinum and of other refractory metals was employed; but these become melted or disintegrated at too low a temperature to let them serve as efficient sources of light. Carbon rods also had been used, but the matter was not brought to a practical issue till 1879, when Mr Edison (and, almost at the same time, Mr Swan) made lamps in which the incandescent conductor was a fine thread or filament of carbon, inclosed in a glass globe, from which the air was exhausted as completely as possible. The filament was originally formed by carbonising a thread of paper, cotton, bamboo, or other vegetable fibre: it is now more usually made by forcing a semi-fluid preparation of cellulose through a die, bending and drying the thread, and heating it to a very high temperature, surrounded with plumbago, in a crucible. The ends of the filament are attached to short conducting wires of platinum, which are sealed into the globe. By making the filament longer or shorter, thicker or thinner, the lamp is adapted to be used with more or less electromotive force, and to give more or less light. The lamp has a limited life, for the filament undergoes a slow process of disintegration, which finally breaks it. As in the case of an arc lamp the power consumed is measured by the product of the current and the electromotive force or difference of potential between the terminal. In ordinary use incandescent lamps consume from three to four watts per candle of light, and last for some 1500 hours. One may force them to a higher efficiency by increasing the electromotive force, so that the temperature of the filament is further raised, and the light is much increased with the expenditure of but little additional power. But this shortens the life of the lamp, and tends also to make a deposit of carbon particles form on the inside of the glass. The temperature of the filament is in no case so high as that of the electric arc; hence incandescent lighting is less efficient than arc lighting as regards the proportion of light to power, and the colour of the light is more yellow. But in point of steadiness and pleasantness, facility for distributing light, and convenience in placing and management, incandescent lamps have many claims to be preferred for indoor use.

An interesting part of the manufacture of lamps is the process of 'flashing' invented by Messrs Sawyer and Mann, which means the electric heating of the filament for a short time in a hydrocarbon atmosphere. The high temperature of the filament causes the dissociation of the gas in contact with it, and the carbon of the dissociated gas is deposited on the filament. This forms a convenient means of adjusting its thickness and resistance; it also tends to make the filament more uniform, for the process of dissociation and deposit goes on most actively at those places which are thinnest to begin with, and therefore hottest. Incandescent lamps work well with either continuous or alternating currents. They are now made of all sizes, from the miniature lamps of one candle power or less which are employed in surgery, up to two or three thousand candle power. When a number of them are used together they are almost always grouped in parallel. In the electric lighting of a house, for instance, positive and negative main conductors, consisting of insulated copper wire, are led from the dynamo, and to these the positive and negative branches are respectively connected, whose ramifications extend to every room. Wherever a lamp is to be placed a positive and a negative leading wire must come, and each lamp forms as it were a bridge between the positive and the negative side of the system. The difference of potential is nearly the same for all; it is a little less in the case of the more distant lamps, because a certain fall in the difference of potential is incurred through the resistance which the leading wires themselves offer to the passage of the current. This loss has to be kept within reasonable limits by making the sectional area of the leading wires great enough, and no serious difficulty is experienced in doing this when the lamps all lie within a few hundred feet of the source. But the difficulty becomes serious when distribution is attempted on a large scale. Not only is the loss of energy in the conductors then a large part of the whole energy supplied, but it may give rise to wider variations in the potential than can be tolerated. If the number of lamps in use in any district were nearly constant, so that a nearly constant current would flow through the mains leading to that district, it would be easy to allow for the fall of potential in those mains. But this fall is itself a variable quantity, depending on amount of the local demand; and to keep the potential sufficiently constant requires mains of large size, the cost of which becomes prohibitory when the area of distribution is much extended.

In such cases it is necessary to resort to other methods of distribution than by a simple system of parallel mains and branches. A sufficient number of sub-centres may be taken over the area to be lighted, and each of these made the starting-point of a system of parallel conductors, the sub-centres themselves being fed from the central source, through independent mains, with currents which are regulated to produce the necessary potential at each sub-centre. Even then, however, if the sub-centres are widely distant from the source the loss of energy in the mains will be serious. In distribution over a large area there is an obvious advantage in very high potential, for the same amount of electrical energy is then conveyed by a smaller volume of current, and consequently with less loss in the conductors. This advantage may be secured if we convey the electric energy to sub-centres in the form of small currents at a high potential, and convert it there into low-potential currents suitable for domestic use. Two plans of doing this have been put in practice—one, by means of storage batteries, is suitable for continuous currents; the other, by means of transformers, is suitable for alternating currents.

Storage Batteries are cells consisting of large sheets or grids of lead, superficially coated with oxide, which are immersed in dilute sulphuric acid, and are polarised by the passage of the current. Peroxide of lead is formed on the positive plates, and spongy metallic lead on the negative. After being charged by the passage of the current the cells will act for a time as electric generators, giving a current in the opposite direction until the plates again become inactive, when they may be again charged. The electric energy given out when the cells are discharging is somewhat less, but need not, if the cells are slowly charged, be very much less than the energy expended in charging them. Each cell has an electromotive force of about two volts, and its internal resistance is made low by grouping a number of pairs of plates in parallel within a single cell (fig. 3). When such cells are used to convert an electrical supply from high to low potential, they are grouped in series while they are being charged, and the groups are then broken up into sections which may be discharged separately or connected in parallel for discharge. Apart from this use of storage batteries in electric lighting, they form a most valuable, but unfortunately very costly adjunct in domestic and other installations for steadying the electromotive force of the supply when used as a shunt across the terminals of the dynamo, and for storing electricity for use during intervals when the dynamo is not running. Small storage batteries have been successfully employed as a means of providing portable electric lamps for use in houses, carriages, and especially in mines. The miner's lamp is a small storage battery weighing a few pounds, and is inclosed in a watertight case no bigger than an ordinary lantern, in the front of which is fitted a small incandescent lamp protected by a stout glass cover. Primary batteries have also been used, in place of storage batteries, to supply electricity to portable lamps.

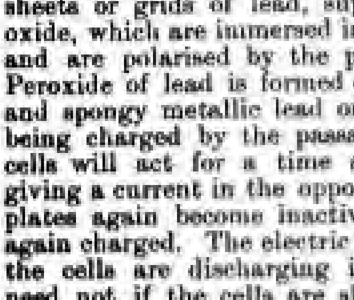


Fig. 3.

Transformers are induction coils, consisting of a core of soft iron on which two coils of insulated copper-wire are wound. When alternating currents are made to pass through one of these, called the primary coil, they produce corresponding periodic alternations of magnetism in the iron, and induce alternating currents of corresponding period in the other or secondary coil. The effect of the iron is to increase the coefficient of mutual induction between the two coils. When the number of windings in the secondary coil is small compared with the number of windings in the primary coil, the electromotive force induced in it is correspondingly smaller than the electromotive force impressed upon the primary; and this is taken advantage of in practice in the conversion of a high-potential into a low-potential supply for electric lighting. In order that the iron core should have as much magnetic susceptibility as possible, it is made in the shape of a ring or some other closed (poleless) magnetic circuit, and to prevent waste of energy by the induction of currents in the substance of the iron, the core is laminated by being built up of thin plates or of wire. Even then, however, there is some waste of energy in the core on account of what is called magnetic hysteresis in the periodic changes of magnetism it undergoes, and some further waste occurs through the heating of both the primary and secondary coils in consequence of the resistance they offer to the conduction of the currents. Notwithstanding these sources of loss the efficiency of a transformer working under favourable conditions is very high, as much as 90 and even 95 per cent. of the energy expended in the primary coil being given off in the converted currents from the secondary. In practice the direction of the current is reversed about 150 or 200 times per second.

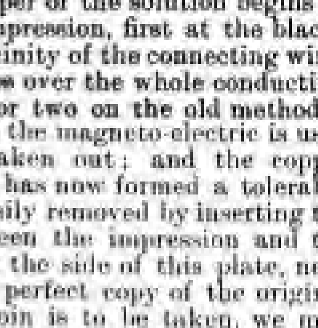
Distribution of electricity for the purpose of lighting by means of transformers, high potential being used in the conveyance of the currents from the distant source, with conversion to low potential before use, has been effected on a fairly large scale in many places, especially in America, where the system has later taken practical shape in the hands of Mr Westinghouse. In London the same method has been successfully employed for some years over a pretty wide area by the Grosvenor Gallery Company, and now (1889) preparations are far advanced for its being applied on a hitherto unprecedented scale by the Electric Supply Corporation, from whose central station at Deptford alternating currents are to be conveyed to all parts of London at a potential of 10,000 volts, to be reduced to 100 volts or so by two successive conversions in transformers before they reach the lamps of the consumers.

Among the minor adjuncts in electric lighting, an important part in guarding against possible risk of fire is played by the 'cut-outs,' whose function is to interrupt the current in any main or branch conductor should it ever exceed a safe strength—as might happen in the event of an accidental cross-connection or short-circuit being formed between the wires. The usual form of cut-out is a safety fuse, consisting of a short piece of foil or wire made of lead or of some fusible alloy which any dangerous excess of current will melt, and so interrupt the current, in that portion of the system which is guarded by the cut-out, before any damage is done. Cut-outs are generally put at the junction of branch with main wires, as well as in the mains themselves. Where the amount of current to be passed is large, an electro-magnetic cut-out is often preferred to a fuse.

Numerous forms of *meter* have been devised for measuring and recording the quantity of electricity supplied to consumers, some suited for continuous currents only, and others for alternating as well as continuous currents. Space does not admit of any description of the ingenious meters invented by Ferranti, Aron, and others. In Edison's meter for continuous currents, which has done good service in central station lighting on the parallel system in New York, the amount of electricity which passes is measured by the deposit of metal in an electrolytic cell. In Forbes's meter, which acts equally well with continuous or alternating currents, the current heats a small coil of wire so that a stream of warm air rises from it; this is made to turn a little windmill, whose number of revolutions is registered, and is found to be a good index of the amount of current which has passed.

Electro-metallurgy is the art of depositing, electro-chemically, a coating of metal on a surface prepared to receive it. It may be divided into two great divisions—electrotype and electroplating, gilding, &c., the former including all cases where the coating of metal has to be removed from the surface on which it is deposited, and the latter all cases where the coating remains permanently fixed. Gold, platinum, silver, copper, zinc, tin, lead, cobalt, nickel, can be deposited electrolytically.

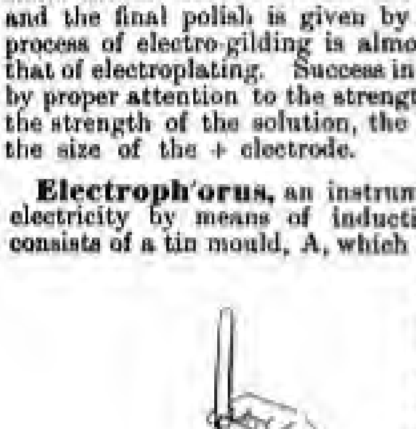
Electrotype is the art of copying printing type, woodcuts, seals, medals, engraved plates, ornaments, &c, by means of the galvanic current in metal, more especially copper. Suppose we wish to copy a seal in copper; an impression of it is first taken in gutta-percha, sealing-wax, fusible metal, or other substance which takes, when heated, a sharp impression. While the impression—say, in gutta-percha—is still soft, we insert a wire into the side of it. As gutta-percha is not a conductor of electricity, it is necessary to make the side on which the impression is taken conducting; this is done by brushing it over with plumbago by a camel-hair brush. The wire is next attached to the zinc pole of a weakly charged Daniell's cell, and a copper plate is attached by a wire to the copper pole of the cell; or, as is now usual, the current required is supplied by Dynamo-electric Machines (q.v.). When the impression and the copper plate are dipped into a strong solution of the sulphate of copper, they act as the – and + electrodes. The copper of the solution begins to deposit itself on the impression, first at the black-leaded surface in the vicinity of the connecting wire, then it gradually creeps over the whole conducting surface. After a day or two on the old method—after a few hours when the magneto-electric is used—the impression is taken out; and the copper deposited on it, which has now formed a tolerably strong plate, can be easily removed by inserting the point of a knife between the impression and the edge of the plate. On the side of this plate, next the matrix, we have a perfect copy of the original seal. If a medal or coin is to be taken, we may proceed in the same way, or we may take the medal itself, and lay the copper on it. In the latter case, the first cast, so to speak, that we take of each face is negative, showing depressions where the medal shows relief; but this is taken as the matrix for a second copy, which exactly resembles the original. The adhesion between the two is slight, and they can be easily separated. The cell of a battery is not needed to excite the current. A galvanic pair can be made out of the object to be coated and a piece of zinc. The figure shows how this may be done. B is a glass vessel containing sulphate of copper; A is another, supported on B by a wire frame, and containing a weak solution of sulphuric acid. The glass vessel A is without a bottom, but is closed below by a bladder. A piece of zinc, Z, is put in the sulphuric acid, and a wire, D, coated with insulating varnish, establishes a connection between it and the impression, C, which is laid below the bladder.



Electrotype is of the greatest importance in the arts; by means of it duplicates in copper of pages of type are obtained, as is done with this Encyclopædia; engraved copper plates may be multiplied indefinitely, so that proof-impressions need be no rarity; woodcuts can be converted into copper; bronzes can be copied; and similar like applications are made of it too numerous to mention. By connecting a copper plate ready for corrosion with the + pole, and making it a + electrode, it can be etched with more certainty than with the simple acid, and without the acid fumes.

Electroplating.—This is the art of coating the baser metals with silver by the galvanic current. It is one theoretically of great simplicity, but requires in the successful application of it very considerable experience and skill. Articles that are electroplated are generally made of brass, bronze, copper, or nickel silver. The best electroplated goods are of nickel silver. When Britannia metal, iron, zinc, or lead are electroplated, they must be first electro-coppered, as silver does not adhere to the bare surface of these metals. Great care is taken in cleaning the articles previous to electroplating, for any surface impurity would spoil the success of the operation. They are first boiled in caustic potash to remove any adhering grease; they are then immersed in dilute nitric acid to dissolve any rust or oxide that may be formed on the surface; and they are lastly scoured with fine sand. Before being put into the silvering bath, they are washed with nitrate of mercury, which leaves a thin film of mercury on them, and this acts as a cement between the article and the silver. The bath where the electroplating takes place is a large trough of earthenware or other non-conducting substance. It contains a weak solution of cyanide of silver in cyanide of potassium (water, 100 parts; cyanide of potassium, 10 parts; cyanide of silver, 1 part). A plate of silver forms the + electrode; and the articles to be plated, hung by pieces of wire to a metal rod lying across the trough, constitute the – electrode. When the plate is connected with the copper or + pole of a one or more celled galvanic battery, according to the strength required, or subjected to the magneto-electric current, and the rod is joined with the zinc or – pole, chemical decomposition immediately ensues in the bath, the silver of the cyanide begins to deposit itself on the suspended objects, and the cyanogen, liberated at the plate, dissolves it, re-forming the cyanide of silver. According, then, as the solution is weakened by the loss of the metal going to form the electro-coating, it is strengthened by the cyanide of silver formed at the plate. The thickness of the plate depends on the time of its immersion. The electric current thus acts as the carrier of the metal of the plate to the objects immersed. In this way, silver becomes perfectly plastic in our hands. We can by this means, without mechanical exertion or the craft of the workman, convert a piece of silver of any shape, however irregular, into a uniform plate, which covers, but in no way defaces, objects of the most complicated and delicate forms. When the plated objects are taken from the bath, they appear dull and white; the dullness is first removed by a small circular brush of brass wire driven by a lathe, and the final polish is given by burnishing. The process of electro-gilding is almost identical with that of electroplating. Success in either is attained by proper attention to the strength of the battery, the strength of the solution, the temperature, and the size of the + electrode.

Electroph'orus, an instrument for obtaining electricity by means of induction. It generally consists of a tin mould, A, which in practice is kept in connection with the ground, filled with shell-lac or resin, B, and a movable metal cover, C, with a glass handle, D, as shown in the fig. The shell-lac is poured in when melted, and is mixed with some other substance to make it less brittle. When the apparatus is used, the surface of the resin or the shell-lac is smartly beaten with cats' fur. This electrifies the resin negatively. When the cover is brought near the lower part of the apparatus, it is charged positively on its under surface, negatively on its upper. If then it is touched, the negative escapes, and the cover is charged with + electricity; and if removed and applied to any conductor, it will give a positive charge to it. The process may be repeated for a great number of times with only a small diminution of B's charge, except by connection or dampness. It is usual to have the earth connection made by a metallic pin passing through B to A, or by a piece of tinfoil, *e*, pasted extending slightly over B, and connected with A.



Electrophorus.

Electroplating, Electrotype. See ELECTRO-METALLURGY.

Electrum (amber; Gr. *ēlektron*) is a term also applied to native gold as it is associated with silver.

Electuary, a form of medicinal preparation in which the remedy is enveloped or suspended in honey or syrup, so as to make a thick, semi-fluid mixture.

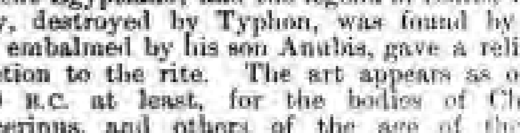
Elements, CHEMICAL, the simplest known constituents of all compound substances. Chemists regard as elementary substances or elements only those substances which have not been proved to be compound. It is not inconceivable that some of the substances at present designated elements (for list of known elements, see ATOMIC THEORY) may hereafter be proved to consist of more than one simple kind of matter, but in the meantime they are correctly called elements, as that term is applied above. The elements are somewhat arbitrarily divided into non-metals and metals, the latter forming by far the larger class. There is no sharp line of demarcation between the two classes, several elements occupying positions on the border line. The elements commonly classed as non-metals are thirteen in number, and are as follows: Hydrogen, chlorine, bromine, iodine, fluorine, oxygen, sulphur, selenium, boron, nitrogen, phosphorus, carbon, silicon. Hydrogen, however, in its chemical relations behaves like a metal. Speculation at present is on the whole rather favourable to the view that all the elements are composed of one fundamental elementary substance (see also CHEMISTRY, and METALS). The time-honoured 'Four Elements' of the Greeks—air, fire, water, earth—are discussed at EMPEDOCLES. The 'Shoo-king,' a Chinese work older than Solomon, has five elements—water, fire, wood, metal, earth. The Indian Institutes of Manu have also five—subtle ether, air, fire, water, and earth.

Elixir (Arab. *el iksir*, 'the philosopher's stone;' see ALCHEMY), a term in pharmacy which has come down from the days of Alchemy (q.v.). By the alchemists the term was applied to various solutions employed in the attempt to transmute metals. But the most notable elixir, sought after by many, was the *elixir vitæ*, 'the elixir of life,' that sublime, potent, perfect, invaluable preparation which, if discovered, would confer immortality or at least extreme length of life on him who drank it. The name has recently been appropriated to a class of American pharmaceutical preparations. These are very different from the old-fashioned elixirs, which corresponded in the main to our modern tinctures; for in the American elixirs the first object sought is to present the medicine under an agreeable form, even if frequently with a loss of potency. These newer elixirs are often highly alcoholic, and are sweetened and flavoured with great skill. In British pharmacy, *Elixir of Vitriol* is almost the only representative of the old class, and is prepared by mixing together sulphuric acid, alcohol, tincture of ginger, and spirit of cinnamon. This preparation, also known as aromatic sulphuric acid, is useful for quenching thirst, sharpening the appetite, checking profuse perspiration, and often reducing the action of the pulse. The dose may range from ten to forty drops, administered in syrup or water.

Elmo's-Fire, ST, is the popular name of an electric appearance sometimes seen, especially in southern climates during thunder-storms, of a brush or star of light at the tops of masts, spires, or other pointed objects. It is also observed at the tops of trees, on the manes of horses, and occasionally about human heads. It is similar in kind to the luminous glow seen at the point when a lightning-rod is working imperfectly, or when there is any very rapid production of electricity (see ELECTRICITY). In the four years 1884–87 eleven cases of St Elmo's fire were recorded at the Ben Nevis observatory. The phenomenon, as seen at sea, was woven by the Greeks into the myth of Castor and Pollux, and was regarded as of friendly omen. The name of *Elmo* is by many thought to be a corruption of that of Helena, the sister of Castor and Pollux. Others take it to be a corruption of St Erasmus, a Syrian bishop and martyr of the 3d century (Italianised, *Ermo*, *Elmo*). The phenomenon has also been called the fire of St Elias, of St Clara, of St Nicolas, and of Helena, as well as *composite*, *composant* or *corposant* (i.e. *corpus sanctum*).

Elutriation is the term applied to the process of separating, by means of water, the finer particles of earths and pigments from the heavier portions. The apparatus generally used is a large vat, in which grinding wheels revolve; and the substance to be reduced to powder being placed in the vat along with water, the wheels in revolving not only pulverise the material, but from their motion being communicated to the water the latter is enabled to retain in mechanical suspension the finer particles of the clay, &c. By allowing a stream of water to flow in and out of the vat, the finer particles can be constantly floated away, and the liquid being run into settling vats, the fine powder settles to the bottom, when the water can be run off from the surface. This process is much employed in the manufacture of the materials used in pottery, and in the preparation of pigments.

Embalming (so named from the balm or balsam often employed), the art of preserving the body after death, invented by the Egyptians, whose prepared bodies are known by the name of mummies, and are called in the hieroglyphs *sahu*, and by St Augustine *gabbaræ*. This art seems to have derived its origin from the idea that the preservation of the body was necessary for the return of the soul to the human form after it had completed its cycle of existence of three or ten thousand years. Sanitary reasons may also have influenced the ancient Egyptians; and the legend of Osiris, whose body, destroyed by Typhon, was found by Isis, and embalmed by his son Anubis, gave a religious sanction to the rite. The art appears as old as 4000 B.C. at least, for the bodies of Cheops, Mycerinus, and others of the age of the 4th dynasty, were embalmed. One of the earliest



Egyptian Mummy.

embalmments recorded in literature is that of the patriarch Jacob; and the body of Joseph was thus prepared, and transported out of Egypt. The process has been described by Herodotus and Diodorus; but their accounts are only partially confirmed by an examination of the mummies. A scribe marked with a reed-pen a line on the left side beneath the ribs, down which line the *paraschistes*, or ripper of the district (an officer of low class), made a deep incision with a rude knife of stone; he was then pelted with stones, and pursued with curses. The *taricheutes*, or salter, next proceeded to remove the entrails and lungs, with the exception of the heart and kidneys, while a colleague extracted the brain through the nose. The body was ready for the salts and spices necessary for its preservation, the quality of which depended upon the sum to be expended. When Herodotus visited Egypt, three methods prevailed: the first, accessible only to the wealthy, consisted in passing peculiar drugs through the nostrils into the cavities of the skull, rinsing the belly in palm-wine, and filling it with myrrh, cassia, and other substances, and stitching up the incision in the left flank. The mummy was then pickled in natron for seventy days, and then washed and elaborately bandaged up in rolls of linen, cemented by gums, and set upright in a wooden coffin against the walls of the house or tomb. This process cost a silver talent, perhaps equal to £725 of our money. A cheaper process, by means of an injection of cedar-oil, cost a *mina*, relatively worth about £243. The poorer classes washed the corpse in myrrh, and salted it for seventy days. When thus prepared, and covered with a pictorial representation of the deceased, attired as a labourer in the world to come, and duly labelled as a 'justified Osiris,' the mummy was placed in a costly coffin (see SARCOPHAGUS) ready for sepulture, but was frequently kept some time before being buried—often at home—and even produced at festive entertainments, to recall to the guests the transient lot of humanity. All classes were embalmed, even malefactors; but various methods were employed besides those mentioned by Herodotus. Some mummies are found merely dried in the sand; others salted by natron, or soaked in bitumen (Jew's pitch) with or without the flank incision, having the brains removed through the eyes or base of the cranium, with the viscera returned into the body, placed upon it, or deposited in jars in shapes of the genii of the dead, the skin partially gilded, the flank incision covered with a tin plate, the fingers cased in silver, the eyes removed and replaced. So effectual were some of these processes that after 2000 or 3000 years the soles of the feet are still elastic and soft to the touch. The sacred animals were also mummied.

Mummy Case of Queen Ahmes Nofretari: Height 9 feet. (From Maspero's *L'Archéologie Égyptienne*.)

but by simpler processes than men. It has been computed that since the practice began in 4000 B.C., down to 700 A.D., when it practically ceased, probably as many as 730,000,000 bodies were embalmed in Egypt; of which many millions are yet concealed. Important finds are made from time to time, as in 1881, when upwards of thirty mummies of potentates, including that of Rameses II., were discovered together at Deir-el-Bahari. Mummies, it may be observed in passing, were used in the 15th and 16th centuries of the Christian era for drugs and other medical purposes, and as nostrums against diseases, and a peculiar brown colour, used as the background of pictures, was obtained from the bitumen.

Other less successful means of embalming were used by nations of antiquity. The Persians employed wax; the Assyrians, honey; the Jews, aloes and spices; Alexander the Great was preserved in wax and honey, and some Roman bodies have been found thus embalmed. The Guanches, or ancient inhabitants of the Canary Isles, used an elaborate process like the Egyptian; and desiccated bodies, preserved by atmospheric or other circumstances for centuries, have been found in France, Sicily, England, and America, especially in Central America and Peru. In Burma the bodies of priests are stuffed with spices and honey and coated with wax and gold-leaf. The art of embalming was probably never wholly lost in Europe; De Bils, Swammerdam, Clauderus, Gooch, Bell, and others attained great success in the art; and a mode of embalming by incisions all over the body is detailed by Penicher. Ruysch, and after him William Hunter, injected essential oils through the principal arteries into the body. Boudet embalmed the bodies with camphor, balsam of Peru, Jew's pitch, tan, and salt. The discovery of Chaussier of the preservative power of corrosive sublimate, by which animal matter becomes rigid, hard, and grayish, introduced a new means of embalming by Beclard and Larrey; but owing to the desiccation, the features do not retain their shape. The discovery of the preservative power of a mixture of equal parts of acetate and chloride of alumina, or of sulphate of alumina, by Gannal in 1834, and of that of arsenic by Tranchini, and of pyroxilic spirits by Babington and Rees in 1839, and of the antiseptic nature of chloride of zinc, have led to the application of these salts to the embalming or preparation of bodies required to be preserved for a limited time. The latest method, by injection of a fluid into the arteries, is described by Dr B. W. Richardson, who has himself embalmed fifty bodies. The process is very common in the United States.

Embryology is that department of biology which reads the development of the individual organism. It is a succession of studies in anatomy and physiology which, when read into unity, give the history of the organism from its earliest individual appearance on to that vague point when it may be said to exhibit all the main features of adult life. The investigation necessarily takes two forms: a description of the structure of successive stages (*morphological*), and an analysis of the vital processes associated with each step (*physiological*). Nor is any embryological investigation complete which does not link the everyday development of individuals with the historical evolution of the race.

History.—Although the development of the chick, so much studied in embryological laboratories to-day, was watched 2000 years ago in Greece, it was only in the scientific renaissance of the 17th century that observation began to grow strong enough to wrestle with conjecture. Harvey, who towered as a strong genius above his contemporaries, and saw much farther, sought in 1651 to establish two main propositions: (1) that every animal was produced from an ovum—*ovum esse primordium commune omnibus animalibus*; and (2) that the organs arose by new formation (*epigenesis*), not from the mere expansion of some invisible preformation. These valuable generalisations were not, however, accepted, and even observations like those of Malpighi seemed for the time to tell against Harvey's prevision. The time was past for absolutely fanciful theories, and yet the dominant doctrine which persisted even into the 19th century was mystical enough. The germ, whether egg or seed, was believed to be a miniature model of the adult. 'Preformed' in all transparency, the organism lay *in nuce* in the germ, only requiring to be 'unfolded.' Just like a bud which hides within its bud the floral organs of the future, so was every germ. 'There is no becoming,' Haller said; 'no part of the body is made from another; all are created at once.' But the germ was more than a marvellous bud-like miniature of the adult; it included all future generations. That germ lay within germ, in ever smaller miniature, after the fashion of an infinite juggler's box, was the logical corollary of the theory of preformation and unfolding. One of the controversies of the time was whether ovum or sperm was the more important. The ovists asserted the claims of the ovum, which only required to be awakened by the spermatozoon to begin its unfolding. The animalculists, on the other hand, maintained that the male element contained the preformed germ, and that the ovum was merely for its preliminary nutriment.

All this was virtually shattered by Wolff (1759), who reasserted Harvey's epigenesis, and showed that the germ consisted of almost structureless material, and that the process of development was a gradual organisation. Yet Wolff's work had not the effect of entirely demolishing preformationist conceptions. They lingered on, and had this much truth in them that the germs are indeed potential, though not miniature, organisms. To some extent Wolff reacted too far against the mystics in his emphasis on the simplicity of the germ, so that a correction was necessary when the cellular character of the reproductive elements was realised about a hundred years later. The observation of structural progress was slow in gaining self-confidence, for it was not till 1817 that Pander took up Wolff's work virtually where he left it. He was immediately reinforced and soon left behind by Von Baer, whose results laid a firm foundation for modern embryology. Since the establishment of the Cell-theory (see CELL) in 1838-39, and the associated researches which showed that the organism starts from a fusion of two sex-cells, and that development consists in the division of the fertilised ovum and differentiation of the results, progress has been both sure and rapid. The more modern demonstration of the fact of evolution has afforded a fresh impulse by its interpretation of the present as the literal child of the past.

The egg-cell or ovum is in all organisms the starting-point of the embryo, but development can rarely begin till this female element is supplemented by the male cell or spermatozoon. These sex-cells are liberated units of the parent-organism, but in most cases they stand in marked contrast to the great congeries of cells which form the 'body.' All the component units of the organism are indeed lineal descendants of a fertilised ovum, but the 'body'-cells become greatly changed into muscle, nerve, skeleton, and the like, while the reproductive cells retain with more or less intactness the characters of the original parent germ. It is this fact which makes the reproduction of like by like possible.

The unicellular animals or Protozoa, having obviously no 'body,' are directly comparable to the sex-cells of higher animals. The 'body' is the addition which makes the difference. In a few Protozoa, however, the results of the division of a unit remain associated together, and a loose colony of cells arises. Such a Protozoon behaves like an ovum or like a primitive male-cell in any of the higher animals. The loose colony may be very unstable, and may soon resolve itself into its component units, exactly as the primitive male-cell, which has divided into a clump of spermatozoa, breaks up and sets these active units free. But the colony may be more stable and retain its continuity (like a segmented ovum), thus bridging the gulf between unicellular and multicellular organisms. In such cases certain cells are set apart as reproductive, and eventually set adrift to start a fresh colony. This is the beginning of the differentiation of special reproductive cells. At first these were probably all alike and able to develop of themselves, but in a manner which does not concern us here (see SEX) they became differentiated as male and female elements, mutually dependent and complementary.

The ovum has all the essential characters of an ordinary animal cell. The cell-substance consists of Protoplasm (q.v.) and of material ascending to or descending from that climax. As in other cases, the cell-substance may be traversed by a network,—one of the intricacies which modern microscopic technique has revealed. Like other cells, the ovum includes a central differentiation or nucleus, technically called the germinal vesicle. This exhibits the essential nuclear elements in the form of rods, bands, or network, and other minute features described in the article CELL. The nucleus plays a most important part in the history of the ovum, and is believed to be the bearer of the hereditary characteristics.

As to the precise origin of the ova, it is enough here to state that in sponges they are simply well-fed cells in the general substance (middle stratum) of the sponge; that in Cœlenterates they may originate from outer or from inner layer; while in other animals they are almost always associated with the middle layer of the body, and as we ascend are more and more restricted to a distinct region or to a definite organ—the *ovary*.

The very young ovum is often at least like an Amœba (q.v.), and in Hydra (q.v.) this character persists. The first chapter in its history is one of nutrition and growth. This often occurs at the expense of neighbour cells, and the ovum may be the successful survivor of a clump. In other cases the nutriment, for immediate or future use, may be derived from the vascular fluid of the animal, or from special glands, which are sometimes simply degenerate portions of an originally larger ovary. The capital of nutriment thus derived is distinguished as the yolk. It varies greatly in quantity and disposition, and has great influence in determining the precise form which the future division of the ovum will take. It may be small in quantity and uniformly diffused through the cell, as in mammalian ova; there may be a larger quantity, which sinks to the lower part, as in frog spawn; there may be a very large amount, which quite dwarfs the genuine living matter, as in birds' eggs; or there may be a central accumulation, as in crustaceans and insects. The egg is very generally surrounded with some membrane, sheath, or shell, made by itself, or contributed by surrounding cells, or the product of special glands. In such envelopes there is often a special aperture (micropyle) through which alone the spermatozoon can enter. Hard shells like those of birds' eggs must obviously be formed after fertilisation has taken place.

The Male-cell or Spermatozoon.—In the unicellular organisms, among which we find the key to all beginnings, two cells, unable apparently to live independently, unite, and thus make a fresh start. In such cases the two units are usually similar in appearance, though doubtless different in chemical state. Sometimes, however, a small active cell unites with a larger and more passive neighbour, and here we find the first hint of the profound difference between the sexes—a difference of which the contrast between spermatozoon and ovum is literally a concentrated expression.

The spermatozoon is a true cell, though the nuclear portion often predominates over the cell-substance. It is one of the smallest animal cells,

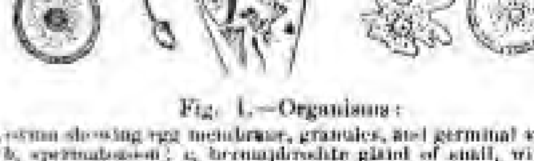


Fig. 1.—Organisms:

a, ovum showing egg membrane, granules, and germinal vesicle; b, spermatozoon; c, hermaphrodite gland of snail, with ova and sperms; d, amoeboid ovum; e, coalescence of sperm-cell and egg-cell.

as the ovum is one of the largest; it is highly active, while the ovum is peculiarly passive; it rarely bears any nutritive material, while the ovum is very generally weighted with yolk. In its minute size, active locomotor energy, and persistent vitality, the sperm-cell resembles a flagellate Monad among Protozoa, while the ovum is strictly comparable to an Amœba or to one of the yet more passive or encysted forms. In most animals the spermatozoon exhibits three distinct parts: (*a*) the 'head,' or essential portion, consisting almost wholly of nucleus; (*b*) the mobile 'tail' of contractile protoplasm which drives the 'head' along; and (*c*) a small middle portion connecting the head and tail.

In its origin the male-cell resembles the ovum, and the two cells are of course the physiological complements of one another. In history, however, the ovum is strictly comparable not to the sperm, but to the cell which divided to give rise to the sperms. The primitive-male-cell, or mother-sperm-cell, is the homologue of the ovum. Just as the latter divides in segmentation, so the mother-sperm-cell divides, and the divisions exhibited in what is technically called spermatogenesis are closely parallel to the various modes of segmentation exhibited by ova. The mother-sperm-cell segments, but the results have no coherence; they go asunder as spermatozoa. Thus, though all cells may be said to rank as equals, the sperm-cell has a longer history behind it than the ovum. The differences both in form and history express the great differences in chemical constitution which are summed up in the words male and female.

Maturation of the Ovum.—The egg-cell having attained its definite size or limit of growth, usually exhibits a somewhat enigmatical phenomenon known as the extrusion of polar globules. In the great majority of cases it buds off two tiny cells, by a true process of cell-division, in which the nucleus plays its usual orderly part. This extrusion is probably universal, but has not yet been observed in bird or reptile eggs. The polar cells come to nothing, though they may linger for a while in the precincts of the ovum. Their expulsion usually takes place before fertilisation has even begun, but sometimes is subsequent to the entrance of the spermatozoon into the ovum. The result of the twofold budding is that the *mass* of the nuclear elements is reduced by three-fourths, though their number appears to remain constant. In many parthenogenetic ova, which develop without fertilisation, Weismann has recently shown that only one polar globule is formed, and this he believes to be constant, and essentially associated with parthenogenesis.

The import of the process is much disputed. Cells do indeed usually divide at the limit of growth (see CELL), but the division here is peculiarly unequal so far as cell-substance is concerned. The marked inequality suggests the theory proposed by Minot, Balfour, and Van Beneden, that the polar globules are male extrusions from the predominantly female egg-cell. The retention of one in parthenogenetic ova is supposed to be what makes independent development possible. The retained polar globule replaces the otherwise necessary sperm. Bütschli looks at the matter rather historically than physiologically, and interprets this premature division of the ovum as the survival of an ancient habit which the mother-sperm-cell still retains. The polar cells are thus rudimentary or abortive female germs. This, however, hardly explains why they should so constantly occur. Weismann supposes the two polar globules to be very different from one another; the first extrudes a nuclear substance which was only useful while the egg was a-making; the second gets rid of half of the essential germ-plasma, the bearer of hereditary characteristics, all in order to make room

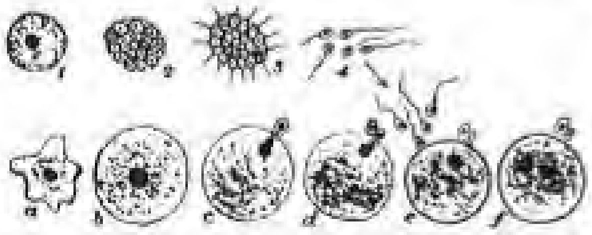


Fig. 2.—Development of Sperms; maturation and fertilisation of Ova (diagrammatic):

1–4, Division of a mother-sperm-cell or primitive-male-cell into a ball of spermatozoa which breaks up; *a–f*, maturation and fertilisation of ovum; *a*, amoeboid young ovum; *b*, later stage; *c*, budding off of a first polar cell; *d*, budding off of a second; *e*, spermatozoa round ovum, one entering; *f*, male and female nuclei about to fuse on completion of fertilisation.

for the addition of a corresponding quantity by the spermatozoon. Parthenogenetic ova only give off the first, and retain all their germ-plasma. Thus they are as able to start in development as fertilised ova which exhibit the circuitous process of first giving half of their germ-plasma away and then getting a similar quantity back from another source. There is no proof that the two extrusions are different in character, and Weismann's theory seems to invest ova with a prevision of the benefits of fertilisation. The simplest view is that the ovum divides at the limit of growth, that the inequality of division expresses an opposition between what is extruded and what is retained, and that this means the getting rid of some waste or male elements. In the differentiation of the male elements both among plants and animals, a parallel but reverse antithesis is often demonstrable.

Fertilisation.—The 'ovists' thought that the ovum was all-important, and only required the sperm's wakening touch to unfold its preformed model. The 'animalculists' were equally certain that the spermatozoon was all-important, and only required to be fed by the ovum. Even after the mutual dependence of the sex-elements had been recognised, the opinion prevailed that contact of the two was unessential, and that by an *aura seminalis* fertilisation was possible. In 1677 Hamm and Leeuwenhoek first distinctly saw spermatozoa; in 1780 Spallanzani showed by artificial fertilisation that the eggs must come into contact with the seminal fluid; in 1843 Martin Barry observed the spermatozoon in union with the ovum of the rabbit; in 1846 Kölliker proved the cellular origin and nucleated character of the male elements; and in 1872–75 Bütschli and Auerbach observed two nuclei in fertilised eggs. The dates of these representative discoveries show how gradually the result has been reached that the essence of fertilisation is the intimate union of a male and female cell.

It is needless to cite the numerous investigators who have made the following statements possible: (1) Only one male element really unites with the egg-cell. By a sudden change after the entrance of one sperm the ovum usually ceases to be receptive. The entrance of more than one occasionally occurs, but the result is pathological. (2) The union is very intimate; the nuclei are at least as important as the protoplasm, and according to most authorities much more so. (3) The two nuclei are attracted or drawn to one another, and fuse intimately to form a single nucleus of double origin. (4) Intimate as the union is, its orderliness is not less conspicuous; half of the result is still traceable to the male and half to the female.

While these are the demonstrable structural facts, what the union means is another matter. Some compare the action of the sperm to a ferment, others to stimulating waste products, while Weismann virtually denies sex differences altogether, and maintains that the union is a mere quantitative addition of the amount of germ-plasma lost in extruding the second polar globule. That the spermatozoon furnishes half of the architectural nuclear substance and thereby half of the hereditary characteristics is certain, that it also affords a chemical stimulus to division it is difficult to doubt. In single-celled animals fertilisation is essential to the continued vitality of the species; in all cases the intimate mingling of sex-elements, different in constitution and past experience, secures both an average constancy and minor variations.

Segmentation.—Soon after the essential act of fertilisation has been accomplished in the intimate union of the nuclei, the egg begins to divide. What physical and chemical attractions and repulsions operate in this process we do not know. It is certain that the nuclear elements, which play a very important part throughout, have what we cannot but call a strong individuality of behaviour. It is certain too that the cell-substance plays an important part, and that it is not merely passive material with which the nucleus operates. Recent observers, led by Van Beneden, have elucidated something of the marvellous interaction between nuclei and cell-substance. It would seem that there is an intracellular muscular system, that from certain centres in the protoplasm strands radiate which moor themselves to the nuclear elements and move them about. It has been further established that the double nucleus of the fertilised ovum is accurately composed half of female and half of male elements. When the egg divides into two, the nucleus of each daughter-cell is again half male and half female, and it is probable that this exact dualism persists yet further.

The different ways in which ova divide depend mainly upon the quantity and disposition of the passive yolk-material. (1) When there is very little nutritive capital, and that uniformly diffused, the whole ovum divides, vertically and horizontally, till a sphere of approximately equal cells is formed. This total segmentation occurs for instance in the ova of sponge, starfish, lancelet, and mammal. (2) In the ova of the frog, where the actual process of division may be most conveniently watched, there is more yolk, which has chiefly sunk to the lower hemisphere of the egg. Division is still total, but after a few segmentations it will be seen that the upper hemisphere cells are dividing more rapidly and are becoming markedly smaller than those in the lower part. The segmentation is total but unequal. (3) In the ova of birds and reptiles and many fishes there is a large quantity of yolk, and the formative substance lies like a drop on the upper surface of the nutrient mass. Division is

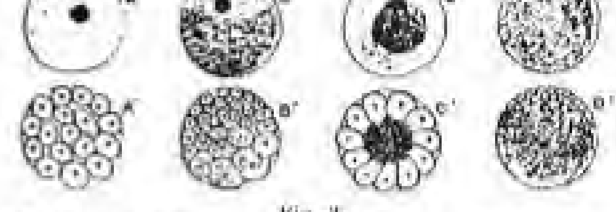


Fig. 3.

Relation of Yolk to division of Ovum (diagrammatic):

A, little and diffuse yolk. A', total equal division.
B, more yolk at lower pole. B', total unequal division.
C, central yolk. C', peripheral division.
D, much yolk. D', partial division.

restricted to the formative protoplasm, and thus the segmentation is conspicuously partial. (4) In the ova of crustaceans, insects, and their allies, the yolk usually accumulates in the centre of the ovum as a more passive, nutritive core, surrounded by the active, formative protoplasm. The latter divides, and forms a sphere or ellipsoid of cells around the less markedly divided yolk. In Peripatus—the survivor of ancestral insects—the whole ovum segments, but the cells are not for a while defined off from one another, so that the result looks like a giant Protozoon with numerous nuclei. Hints of this are seen in other cases.

Morula and Gastrula.—The result of segmentation is a ball of cells, differing according to the above described modes of division. When a wide cavity has been left, between the cells as they multiplied, a hollow sphere is formed, technically called a *blastosphere*; if no such conspicuous 'segmentation cavity' has been left the result is an almost solid mulberry-like ball of cells—a *morula*. When the division is partial, mainly confined to an area of formative protoplasm lying upon a nutritive mass, the result is a disc of cells which by and by spreads round the yolk. Such a segmented area is generally known as the *blastoderm*. (See D', fig. 3.)

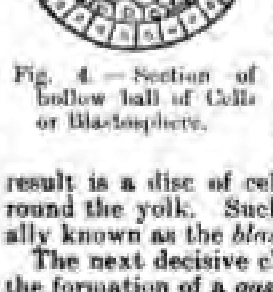


Fig. 4.—Section of hollow ball of Cells or Blastosphere.

The next decisive chapter is one of infolding, or the formation of a *gastrula*. In the simplest cases one hemisphere of a hollow ball of cells is dimpled or invaginated into the other. More accurately, the one hemisphere sinks into and becomes surrounded by the other. The sphere becomes a two-layered sack or gastrula, with an opening technically called the *blastopore*. In many other cases—e.g. fishes, reptiles, and birds—owing to the yolk, complete invagination is not possible. An infolding still occurs, but it is no longer conspicuous, and the gastrula-stage is thus disguised. It must also be noted that the two-layered condition may arise by *arrangement* of the cells, without there being any process that can be called invagination. Thus, in the oval ciliated embryo or *planula* of most Hydrozoa, the two layers have been frequently observed to arise by a process of internal differentiation, known as *delamination*.

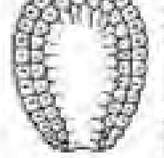


Fig. 5. Gastrula: Showing ectoderm, ciliated endoderm, blastopore, and central cavity.

The Germinal Layers.—Even in a simple colony of cells like a Volvox all the units do not remain alike. Inside cells are in different conditions from outside cells, and division of labour with consequent difference of structure is bound to occur. So again, in the ball of cells into which the ovum divides, the one hemisphere with heavier material is usually different from the upper hemisphere, which is specifically lighter and less encumbered with reserve material. Even in the morula or blastosphere differentiation has begun.

But we have just seen that by the folding of one hemisphere into the other, or in other ways, a gastrula often more or less modified arises. The embryo thereby attains definitely differentiated layers—outer and inner. The preformationists spoke of development as an unfolding; we now insist on an infolding. The layered character of the embryo was early recognised by Wolff, and yet more clearly by Pander and Von Baer, but its fundamental import can hardly be said to have been realised till Huxley in 1849 compared the outer and inner cell-layers of Cœlenterates (hydroids, jelly-fish, &c.) to the outer and inner layers which embryologists had begun to demonstrate in development. Soon afterwards Allman gave to the outer and inner layers of Cœlenterates the names *ectoderm* and *endoderm*, which are now universally used for the outer and inner layers of every embryo. The results reached by Huxley and Haeckel, Kovalevsky and Ray Lankester, and many others, have made it certain that the formation of these two germinal layers is constant in animals, that they are exactly comparable throughout the series, and that with few exceptions they give rise to precisely the same adult structures.

In sponges and Cœlenterates only two genuine layers of cells are developed. A middle stratum, seen in faint suggestion in the common Hydra, may indeed appear between outer and inner layers, and may be of the greatest importance in the structure of the animal, but embryologists are not inclined to allow this middle stratum—the so-called *mesoglœa*—to rank as a distinct layer beside the other two.

In higher animals, however, there is a definite middle layer or *mesoderm* between the other two. Its history involves much greater difficulty than that of the ectoderm and endoderm; it seems as if it might arise in some half-dozen different ways. One common mode of origin has been emphasised by the brothers Hertwig in what they call the 'Cœlome-theory.' The inner layer arises by an infolding of the outer, and a primitive gut-cavity (*archenteron*) thus results. Now begins an out-folding. From the gut-cavity two sacks (*cœlome-pockets*) grow out, one on either side, insinuating themselves between the first two layers. The cavities of the sacks form the future body-cavity of the animal; the outer and inner walls form the corresponding two divisions of the mesoderm. However this middle layer arises, it finally exhibits an inner and an outer division, so that the Hertwigs speak of *four* germinal layers. The outer (parietal or somatic) portion of the mesoderm clings to the external body-wall, forming muscles and the like; the inner (visceral or splanchnic) portion cleaves to the internal organs.

Origin of Organs.—With few exceptions, the same organs and structures arise from the same layers—e.g. the nervous system from the ectoderm, the lining of the mid-gut from the endoderm. (*a*) *The ectoderm or epiblast* gives origin to outer skin or epidermis, external skeleton, superficial glands, sense-organs, nervous system, the infoldings at both ends of the gut, and probably to the primitive excretory (segmental) duct. (*b*) The *endoderm or hypoblast* forms the lining of the mid-gut, and necessarily, too, of outgrowths from it, such as the lungs and various glands. In vertebrates it also gives rise to that important skeletal axis the notochord—which always precedes the 'backbone.' (*c*) The *mesoderm* or *mesoblast* gives rise to all the rest. That is to say, the under-skin, the muscles, the connective tissue, the internal skeleton, the lining of the body-cavity, the heart and the blood, and the like are all mesodermic. The reproductive organs, though to some extent structures by themselves, also arise, in the great majority of cases, in connection with the mesoderm. It must be noted, further, that while the main part of a structure is referable to one of the three layers, the entire structure is very often composite. Thus, the eye of vertebrates mainly arises as an outgrowth from the brain, but some of the less essential parts are furnished by the mesoderm. The outgrowths from the mid-gut are in origin endodermic, but they too are always aided by the middle layer.

Physiological Embryology.—The immense progress of embryology within recent years has been almost wholly morphological. Of the physiological conditions of development we know relatively little. The later stages of embryonic life in higher animals have been studied by Preyer and others with much success, but this is but the threshold of investigation. A few luminous results as to the architectural conditions are due to the courage of His and Rauber, who have followed the earlier suggestions of Pander and Lotze. The task, which is involved in stupendous difficulties, has been continued in the experimental investigations of O. Hertwig, Fol, Pflüger, Born, Roux, Schultze, Gerlach, and others. Observations as to the actual dynamics of cell-division, such, for instance, as those of Van Beneden and Boveri, are beginning to appear; while the title of a recent work by Berthold—*Protoplasmic Mechanics*—shows how the biologist persistently seeks the aid of the student of physics in order to explain the architecture of the living organism. 'To think that heredity will build organic beings without mechanical means' is, according to His, 'a piece of unscientific mysticism;' while Pflüger insists on the conception of development as 'an organic crystallisation.' The laws of growth, which express how each fertilised egg-cell must divide, and how the resulting units must arrange themselves first in layers and thereafter into organs, must be expressed in terms of physical and chemical conditions. But this is the task of the future.

Generalisations.—(1) *The Ovum-theory.*—In all cases of ordinary sexual reproduction among plants or animals the offspring develops from a fertilised egg-cell. This is the ovum-theory prophesied by Harvey in 1651, again almost realised by Wolff in 1759, but only demonstrated about a hundred years later when the organism was at length analysed into its component cells (see CELL). The fact that every plant or animal begins at the beginning again, at the level of the Protozoa or single-celled organisms, Agassiz does not hesitate to call one of the greatest discoveries in the natural sciences in modern times.

(2) *The Gastræa-theory.*—The simplest animals are single cells; these occasionally form loose colonies or balls of cells; next come sack-like two-layered organisms, such as the simplest sponges. These are the first three grades among living animals, but they also correspond to the first three chapters in the life-history of each organism. The single cell (the ovum), the ball of cells (the morula or blastosphere), the sack of cells in two layers (the gastrula), we have seen to be the first three stages in development. As this gastrula-stage always occurs, though sometimes disguised by the yolk, in the life-history of animals, Haeckel justly emphasised it as the individual's recapitulation of an ancestral state. The simplest, stable, many-celled animal he believed to be like a gastrula (see fig. 5), and he called this hypothetical ancestor of all higher animals a gastræa. A few living animals are still almost at this level; all animals pass through it in their gastrula-stage. The gastrula is a recapitulation of the ancestral gastræa. Rival conceptions of what the first stable, many-celled animal was like have been since proposed, but the gastræa-theory still holds the field.

(3) *The Fact of Recapitulation.*—The gastræa-theory is only a special case of a more general proposition—that the individual recapitulates the history of its kind. That the past lives in the present, or that we individually retread, for instance in our intellectual development, the paths made by our ancestors, is a familiar idea which it is one of the charms of embryology to realise in the life-history of each organism. At an early date Von Baer expressed this in his law, that structural progress or differentiation in development was from a general to a special type. 'In its earliest stage,' he said, 'every organism has the greatest number of characters in common with all other organisms in their earliest stages; at each successive stage the class of embryos which it resembles is narrowed.' In the life-history of a mammal it is possible to trace how the germ at first lingers as it were among the Protozoa; how it divides and passes quickly through the transitional 'ball of cells' stage; how the embryo undergoes its first great differentiation, like all other multicellular animals, in becoming a two-layered gastrula, taking its place beside the ancestral Metazoa; how it by-and-by acquires some of the characters of a young worm, and then of a very simple backboned animal, like a primitive fish; how with increasing complexity it ranks with reptilian embryos; and lastly, how the fœtus acquires mammalian features, vague and general at the outset, but gradually becoming like those of nearly related forms. Von Baer himself confessed, as every embryologist would do, that with three embryos of higher Vertebrates at the same stage before him, he could not, without close examination, tell one from the other. The accompanying figure of the embryos of a bird, a mammal, and the human species clearly illustrates this close resemblance in early life.

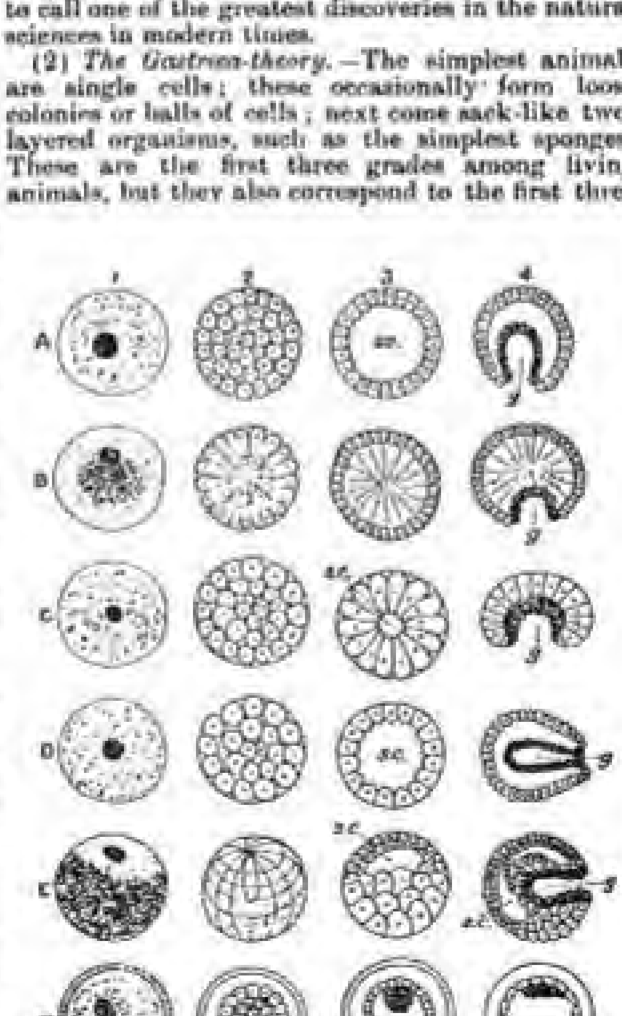


Fig. 6.

The First Stages in Development (not drawn to scale):
1, fertilised ovum; 2, ball of cells; 3, the same still more divided, or in section; 4, the gastrula (except in F); A, sponge, coral, earthworm, or starfish; B, crayfish, or other arthropod; C, river snail, or other mollusc; D, lancelet, tunicate, &c.; E, frog, or other amphibian; F, rabbit, or other mammal; *s.c.*, segmentation cavity; *g*, gastrula invagination; *z.r.*, zona radiata, or porous envelope. Darkly shaded cells are endoderm, lighter are ectoderm, dots are yolk granules.

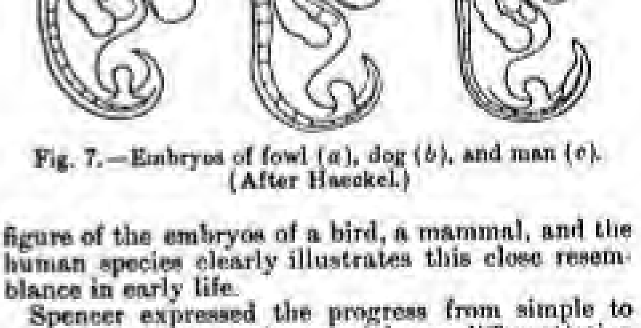


Fig. 7.—Embryos of fowl (*a*), dog (*b*), and man (*c*). (After Haeckel.)

Spencer expressed the progress from simple to complex, from general to special, as a differentiation from homogeneous to heterogeneous, in which the individual history runs parallel to that of the race. The most luminous reading of the fundamental fact is that of Haeckel. The individual development is a recapitulation of the historic evolution of the race. A curve symbolising the turns and twists in the life-history of one of the higher Vertebrates, for instance, is seen to be a reflection of the great bends and branches of the genealogical tree which expresses the historic lineage. The development of the individual microcosm is a summary—often a shorthand summary—of the evolution of the macrocosm of the race. Most pithily, though most technically, he sums up his 'fundamental biogenetic law' in the words 'Ontogeny recapitulates phylogeny.' The fact is very vividly illustrated in many of the more patent life-histories, such as those of crustaceans, insects, and amphibians, where the hatched young follow the rails laid down by their respective ancestors (see AMPHIBIA, CATER-

PILLAR, CRUSTACEA). Parker happily compares watching development—in which he is one of the modern masters—to reading a palimpsest; below the superficial script there are older and ruder characters, and below these more primitive still. Two cautions must be emphasised. The development is often shortened in its path; circuitous twists, in what we believe to have been the historic course, are skipped by the individual; the momentous steps, however, are always paralleled in the two histories. The individual development may be said to follow the main line of progress, but does not go off into side-lines. Thus the resemblance is between embryos. The embryo bird is hardly like a reptile, but it is always in its development like an embryo reptile. Nor must it be imagined that this fact of recapitulation exactly explains itself. That the present is child of the past does indeed shed great light on the individual's recapitulation of ancestral stages, but the metaphors are apt to suggest that the developing organism has somehow a feeling for history, or that the hand of the past is literally upon it as it grows. It is necessary to get beyond mere metaphors of unconcious memory and the like, and to realise that the same internal conditions which in the long past led to certain momentous changes are still really present doing the same for the individual. The fundamental problem is to elucidate the chemical and physical conditions which represent the living hand of the past upon the development of the present, or to understand how the living matter of the embryo is at each stage both the material and the architect of its upbuilding.

(4) *Continuity of Germinal Protoplasm.*—In flowering plants there is a conspicuous contrast between the reproductive system and the general 'body.' In all organisms this antithesis is fundamental, and the recognition of the fact has shed much light upon the problems of development and heredity. In the simplest animals a portion of the cell is separated off to start a new individual; and as this is virtually continuous with the parent the reproduction of like by like is natural and necessary. In a few animals (some worm-types, crustaceans, insects, &c.), when the ovum has multiplied to a limited extent, by the usual process of division, certain of its descendants, as yet very like the original ovum, are set apart to form the reproductive cells of the offspring, and take no share in building up the 'body.' The germ-cells of the offspring, thus early insulated, are in a real sense continuous with the parental ovum; they retain some of the living capital intact, continue the protoplasmic tradition unaltered, and when themselves liberated will naturally do what the original germ-cells did. Thus the reproduction of like by like becomes more intelligible, and we reach the conception of a continuous necklace-like chain of immortal germ-cells from which the mortal bodies of successive generations are budded off. This conception has been more or less clearly suggested by numerous naturalists—Owen, Haeckel, Jäger, Brooks, Galton, Nussbaum, and others, but has been elaborated by Weismann in his theory of the continuity of the 'germ-plasma.' A continuous chain of germ-*cells* is only demonstrable in a few cases; often they become distinct only at a relatively late stage in the development of the offspring. Therefore Weismann insists not on a continuity of germ-cells from those of the parent to those of the offspring, but only on a continuity of 'germ-*plasma*.' 'In each development a portion of the specific "germ-plasma" which the parental ovum contains is not used up in the formation of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generation.' The germ-plasma which keeps up the continuity has its seat in the nucleus, is a substance of definite chemical and special molecular constitution, has an extreme power of persistence and enormous powers of growth. The general idea is simple enough—an offspring starts with a capital of living matter which is virtually the same as that from which its parents started. Therefore the results are in a general way the same, and the constancy of the species is sustained. How this is modified by variations is not here relevant.

Emerald (Span. *esmeralda*, Fr. *émeraude*, Ger. *smaragd*, Gr. *smaragdos*), a mineral generally regarded by mineralogists as merely another variety of the same species with the Beryl (q.v.), with which it essentially agrees in composition, crystallisation, &c., differing in scarcely anything but colour. The emerald, which, as a gem, is very highly esteemed, owes its value chiefly to its extremely beautiful velvety green colour. It is composed of about 67–68 per cent. of silica, 15–18 of alumina, 12–14 of glucina, and minute proportions of sesquioxide of chromium, magnesia, and carbonate of lime. Its colour is ascribed chiefly to the oxide of chromium which it contains. Its specific gravity is 2·70–2·76. In hardness it is rather inferior to topaz. The localities in which the emerald is found are very few. The finest have long been brought from Colombia (q.v.), where they are obtained from veins traversing clay-slate, hornblende slate, and granite; and valuable stones also come from the Upper Orinoco, in Venezuela. Stones of inferior quality are found in Europe, imbedded in mica-schist, in the Heubach Valley, in Salzburg. They also occur in the Urals; and some old mines in Upper Egypt have been found to yield them. This gem, known from very early times, was highly prized by the ancients. Pliny states that when Lucullus landed at Alexandria, Ptolemy offered him an emerald set in gold, with his portrait engraven on it. Many wrought emeralds have been found in the ruins of Thebes. Nero, who was near-sighted, looked at the combats of gladiators through an eye-glass of emerald, and concave eye-glasses of emerald seem to have been particularly esteemed among the ancients. As a precious stone, the emerald is rarely without flaw. Its value also depends much on its colour. A very perfect emerald of six carats has been sold for £1000. It appears not improbable that emeralds have been found in the East, in localities not at present known, but the name Emerald or Oriental Emerald is often given to a very rare, beautiful, and precious green variety of Sapphire (q.v.).

EMERALD COPPER is a beautiful and very rare emerald-green crystallised mineral, also called Dioptase, found first and chiefly in limestone in the hill of Altyn-Tübe (Altai Mountains), and also obtained in the Urals and the South American Cordilleras. It is composed of about 39 parts silica, 50 protoxide of copper, and 11 water.

Emetics, medicines given for the purpose of producing Vomiting (q.v.). They are given when it is desirable to relieve the stomach of some noxious or indigestible substance, such as a narcotic poison, or excess of food, or some special article of diet which has disagreed. Emetics are also administered in cases of fever, where the copious secretion they produce from the glands of the stomach and intestines is supposed to have a directly curative effect, aided, perhaps, by the sedative action of emetics upon the circulation and nervous system. There is a considerable amount of evidence to show that emetics have the power of cutting short typhus and other fevers in the earliest stage, and afterwards of making the attack of the disease less severe. In diseases of the respiratory organs, emetics are given as the quickest and safest method of removing accumulated mucus from the air-passages; and in Croup (q.v.) their action is especially favourable, being often followed by expectoration and a rapid improvement in the suffocative symptoms. Emetics are to be given with great caution, however, in all very depressed states of the system, as their primary action is to produce nausea, which is attended always with more or less diminution of the vital power, and often with great depression of the heart's action, amounting to syncope or fainting. Emetics may produce vomiting either by their local action on the throat, gullet, and stomach, or by their action through the blood on the nervous mechanism regulating the movements of the stomach. They are thus divided into two groups, *local* and *general* emetics; and the depressing effect of the former is much less than that of the latter. Some substances will produce vomiting in either way; so that the distinction between the two classes is not very definite. Among the chief emetics in use are mustard (two tablespoonfuls), common salt (a tablespoonful or more), alum (a teaspoonful), in a tumblerful of water, repeated after a quarter of an hour if necessary. These, with sulphate of copper or zinc, are mainly local in their action; ipecacuanha and emetin, squills, senega, tartar emetic and other soluble salts of antimony, apomorphia, are mainly general in their action. The production of vomiting is aided, whatever emetic is used, by copious draughts of warm water. Tickling the throat with a finger or feather is often an effective mechanical means to produce vomiting.

Emetin is the alkaloid which forms the active principle of ipecacuanha-root. It may be obtained by drying the powdered root-bark with milk of lime, and then exhausting with boiling chloroform. It is a white powder, becoming brown on exposure to light, slightly soluble in water, but readily in alcohol. When taken internally, it exhibits violent emetic properties, $\frac{1}{16}$th of a grain sufficing to cause vomiting. The wood of the root contains no emetin, so that the virtue of ipecacuanha-root entirely resides in the bark.

Emulsin, or SYNAPTASE, is a peculiar ferment present in the bitter and sweet almond, which forms a constituent of all almond emulsions. When bitter almonds are bruised, and water added, the emulsin acts as a ferment on the amygdalin, and decomposes the latter into volatile oil of bitter almonds, prussic acid, grape-sugar, and water (see ALMONDS, VOLATILE OIL). The vegetable albumen of almonds is almost entirely composed of emulsin, which, when separated, is a white substance, soluble in water, and is distinguished by its remarkable power of causing the fermentation of amygdalin. It consists of carbon, hydrogen, nitrogen, and oxygen.

Emulsion is the term applied to those preparations in pharmacy in which oleaginous substances are suspended in water by means of gum, sugar, carrageen, yolk of egg, &c. The production of these emulsions is often not an easy matter, and requires judgment and skill. In general it will be found that the bulk of the emulsifier must first be taken, while the oil should only be added little by little, rubbing together in a mortar, and taking care that it is completely absorbed or emulsified before further additions. Should too much be added, the effect is to throw out most of what has already been incorporated, and it is then almost impossible to remedy the error. The emulsion of cod-liver oil is probably known to all, but there are many emulsions in which solid substances have to be suspended, and to them the directions above given are not always applicable.

Enamel (Fr. *émail*; originally *esmail*, from the same root as *smelt*), the name given to vitrified substances applied chiefly to the surface of metals. Enamelling is practised (1) for purposes of utility, as in making the dial-plates of watches and clocks, coating the insides of culinary vessels, &c.; and (2) for producing artistic designs, portraits, and for ornamental purposes generally. The basis of all enamels is an easily fusible colourless glass, to which the desired colour and opacity are imparted by mixtures of metallic oxides. The mass, after being fused together and cooled, is reduced to a fine powder and washed, and the raw material thus obtained is variously applied to the surfaces to be covered according to the class of enamel being made. The whole is then exposed in a furnace (*fired*, as it is called) till the enamel is melted, when it adheres firmly to the metal. The metal most commonly used as a ground for enamel is copper; but for the finest kinds of enamel-work gold and silver are also used.

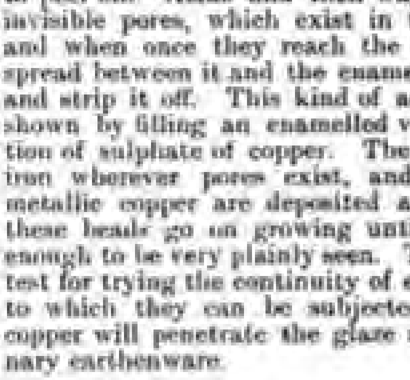
Artistic or Ornamental Enamelling.—This art is of great antiquity; it was to a limited extent practised by the Greeks; but enamels were more largely employed by the Romans, under whose dominion the art passed into Gaul and Britain. Enamelling has also been practised from a remote period in the East, Persia, India, China, and Japan, under a separate and distinct development; but there is nothing from which it can be inferred that the various methods were in use earlier than in Europe. As a decoration enamelling was more popular and attained to greater perfection in the middle ages than in classic times. It was extensively practised at Byzantium from the 4th until the 11th century, and afterwards in Italy, in the Rhenish provinces, and at Limoges in the south of France. The Byzantine and other early styles of enamel-work, down to the 14th century, were generally employed in ornamenting objects connected with the service of the church. Enamel was also greatly used in ornamenting jewelry, and vessels made for use or display in the mansions of the rich, such as salt-cellars, coffers, ewers, candlesticks, &c.; but these objects were principally made in the painted enamels introduced in France towards the end of the 15th century.

Distinguished with reference to the manner of execution, enamel-work may be divided into four kinds: (1) *Cloisonée*, or inclosed, the method of the Byzantine school, in which the design is formed in a kind of metal case, generally gold or copper, and the several colours are separated by very delicate filigree gold bands, to prevent them running into one another. Of this style the grandest example extant is the famous *Pala d'oro* in St Mark's Church, Venice, some portions of which are Byzantine of the 10th century. (2) *Champlevé*, practised by the Rhenish and early Limoges schools. In this process the ornamental design, or the figures which were to be filled in with colour, were cut in the metal (generally copper) to some depth; and wherever two colours met, a thin partition of the metal was left to prevent the colours running into each other by fusion when fired. (3) Translucent enamel, which had its origin and was brought to great perfection in Italy, was composed of transparent enamel of every variety of colour, laid in thin coatings over the design, which was incised on the metal, generally silver, the figure or figures being slightly raised in low relief, and marked with the graver, so as to allow the drawing of the contours to be seen through the ground, instead of being formed by the coarse lines of the copper, as in the early Limoges enamels. (4) Surface-painted enamels, which may be divided into two stages. The first stage, which is known as the late Limoges style, sprang up about 1475, and flourished till 1630. In this the practice was to cover the metal plate with a coating of dark enamel for shadows, and to paint on this with white, sometimes having the hands and other parts of the figures completely coloured. The designs of the middle and best period were generally taken from well-known paintings or engravings of the period, and were strongly influenced by the Italian art of the time. This style soon degenerated, and gave place to the latest or *miniature* style, which was invented before the middle of the 16th century by Jean Toutin, a goldsmith at Châteaudun, and carried to the highest perfection by Jean Petitot, a miniature-painter, who was born at Geneva, 1607, and resided long in England, and then in Paris. On his method the plate is covered with a white opaque enamel, and the colours are laid on this with a hair-pencil, and fixed by firing. The paints are prepared by grinding up coloured enamels with oil of spike, and when fused by the heat, they become incorporated with the enamel of the ground. The earlier enamellers of this school occupied themselves with miniatures, snuff-boxes, watch-cases, and other trinkets, till the period of the Revolution, when the art fell into disuse in France. In England, however, it was carried on with much success; and copies of portraits and pictures on a much larger scale than the French miniatures were executed by Henry Bone (1755–1834), and the German, Karl Muss (died 1824). Works of this description possess the obvious advantage of durability; but those various qualities of texture, and the delicacy of colour for which good works in oil or water-colour are prized, cannot be attained in enamel copies. The greater part of the artistic enamel-work of the present day is of Japanese fabrication, and consists of cloisonné work on a copper basin. Both in Paris and in Birmingham enamel-work of this class has been attempted with success; but designs can be executed in Japan at prices which defy the competition of western traders. In China both cloisonné and painted enamels are made in characteristic Chinese designs. At Jeypore in India a limited quantity of enamel-work on gold is executed in translucent colours which possess incomparable brilliancy. Enamel incrustations of various kinds are very largely used in the jewelry, goldsmith, and silversmith trades of Europe. See Garnier, *Histoire de la Verrerie et de l'Émaillerie* (1886); Bowes, *Japanese Enamels* (1885); and for enamelled earthenware, see the article POTTERY.

Enamelled Iron.—Since the beginning of the 19th century many attempts have been made to cover iron with a vitreous surface, and several patents have been taken for such methods of enamelling. The chief difficulty in applying enamels to iron arises from the tendency of the metal to oxidise before it reaches the temperature at which the enamel fuses, and to become brittle from the oxide combining with the silica of the enamel. This action being superficial, the mischief is the greater in proportion to the thinness of the iron. Therefore it is much easier to enamel thick cast-iron vessels than thin vessels made of sheet-iron. A glass may be made by combining either silicic acid or boracic acid with a base; the latter fuses at a lower temperature than the former, but the glass is much dearer and not so durable as the silica glass. The enamels used for coating iron consist of a mixture of silica and borax, with various basic substances, such as soda, oxide of tin, alumina, oxide of lead, &c. Lead is not, or ought not to be, used in the enamel for coating culinary vessels.

A great variety of articles, many of them beautifully decorated in colours, such as grate-fronts, clock-dials, panels of different kinds, sign-boards, tablets, and name-plates, are now executed in enamelled iron at a moderate cost. It is also applied to corrugated roofing. The effect of heat on enamelled iron especially is to expand the metal more than the enamel, and cause the latter to peel off. Acids find their way through minute invisible pores, which exist in the best enamel; and when once they reach the iron, they rapidly spread between it and the enamel, and undermine and strip it off. This kind of action is curiously shown by filling an enamelled vessel with a solution of sulphate of copper. The acid attacks the iron wherever pores exist, and little beads of metallic copper are deposited at all such spots; these beads go on growing until they are large enough to be very plainly seen. This is the severest test for trying the continuity of enamelled surfaces to which they can be subjected, as sulphate of copper will penetrate the glaze and body of ordinary earthenware.

Epidermis (Gr. *epi*, 'upon,' and *derma*, 'the skin'), scarf-skin or cuticle, forming an external covering of a protective nature for the true skin or corium. Its under or attached surface is accurately moulded upon the true skin, and when the two are separated the cuticle presents impressions which exactly correspond to the elevations and depressions in the corium. The thickness of the epidermis varies from $\frac{1}{17}$ to $\frac{1}{8}$ of an inch, according to the amount of protection which the delicate and sensitive corium requires in different localities. Thus, it is thickest and hardest in the palms of the hands and soles of the feet, but this is not altogether the result of an increased growth due to intermittent pressure, for the difference is well marked even in the fœtus. The epidermis consists of many layers of stratified cells superimposed on each other; and since they cover a free surface exposed to the air, the cells are classed in the group of stratified epithelia. The cells vary in shape, those placed next the corium being elongated in form, while those most superficial are flat and scale-like. On this account it is usual to describe the epidermis as consisting of two strata—an outer or *superficial horny stratum*, and a deeper or *mucous stratum* (or *rete Malpighii*). The *horny stratum* consists of cells, many of which have lost their nuclei and assumed the form of hard flattened scales of polygonal outline. The deepest layer of this stratum consists of closely packed cells with indistinct outlines and a clear, almost homogeneous, appearance, which has given them the name of the *stratum lucidum*. The superficial cells of the horny layer are regularly cast off by desquamation, and replaced by those beneath them. In reptiles and amphibians this layer is periodically cast off in a more or less entire state, a new one being previously formed beneath it; and in man desquamation in large patches occurs after certain diseases, especially scarlet fever.



Perpendicular Section of the Skin of the Leg of a Negro (magnified 250 diameters):

a, a, papillæ of the cutis; b, deepest intensely coloured layer of perpendicularly elongated cells of the mucous layer; c, upper stratum of the same layer; d, horny layer.

The *mucous stratum* lies next the corium. It consists of nucleated cells of various shapes. Those next the corium are elongated and placed perpendicularly to its surface. Above these are cells more rounded or polyhedral in outline, and possessing many spines or prickle-like processes, by the points of which the cells adhere to each other, and thus leave fine lymph channels through which the nutrient plasma is transmitted to the cells. The colouring matter of the epidermis is found in the cells of the mucous stratum. A more or less dark pigment is often deposited in the face, neck, and hands of the fair races of men during exposure to the sun, forming isolated colour-spots called freckles; but in the dark races the pigment-granules are distributed throughout the cells of the mucous stratum, the deepest or perpendicular cells being the darkest. Instances of white negroes are on record, not as a consequence of change of climate, but as an abnormal condition of the epidermis. Fine nerve-fibrils penetrate between the cells of the mucous stratum, and undergo a certain amount of ramification, but do not form a network. In some reptiles, and in the Edentata among mammals, the epidermis forms large plates or scales, while epidermal appendages assume various forms—e.g. hair, nail, spines, bristles, feathers, claws, hoof, horns, &c.

In *plants* the epidermis is formed of flattened cells, usually only one layer deep, frequently bearing hairs and stomata. The exposed cell-walls upon the outer surface are frequently thickened as the cuticle.

Epithelium is the term applied in anatomy to the cell-tissue which, in layers of various thickness, invests not only the outer surface of the body, and the mucous membranes connected with it—as, for example, those of the nose, lungs, intestinal canal, &c.—but also the closed cavities of the body, such as the great serous membranes, the ventricles of the brain, the synovial membranes of joints, the interior of the heart and of the blood-vessels proceeding to and from it, the ducts of glands, &c. The thickness of this tissue varies extremely with the position in which it occurs. In some parts it consists of numerous strata of cells, collectively forming a layer of more than a line in thickness; in other parts it is composed of only a few strata, or often of only a single stratum of cells, and can only be detected by the microscope. The cells of which the epithelium is composed are usually soft nucleated cells; they may be rounded, polygonal, fusiform, cylindrical, or conical in shape, and sometimes they possess vibratile cilia. No blood-vessels exist in epithelial tissues, although minute channels may be found between the cells, by means of which the plasma derived from subjacent blood-vessels may pass for the nutrition of the cells. In many cases nerve fibrils are abundant.

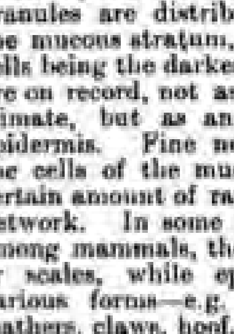


Fig. 1.
Epidermis (still soft like the epithelium of internal parts) of a two months' human embryo. Mag. 350 diam.

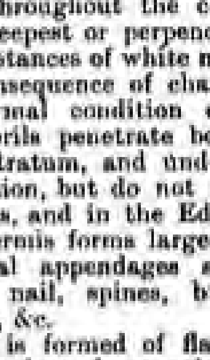


Fig. 2.
Epithelial cells of the vessels; the longer one from the arteries, the shorter ones from the veins.


Fig. 3.
Epithelium of the intestinal villi of the rabbit. Mag. 300 diam.

Epithelia may be classified (*a*) according to the embryonic layer from which they are developed; (*b*) according to their function; (*c*) according to their shape and arrangement. Following the latter method, we have (*a*) *simple epithelium*, consisting of a single layer of cells which may be: (1) *Pavement*, consisting of polygonal plates or scales joined together by their edges. They constitute the variety known as pavement or tesselated epithelium, and occurring as an investment of the serous membranes, of most synovial membranes, of the lining membrane of the heart and of the veins, of the canals of glands, &c. (2) *Columnar or cylinder epithelium*, as in the intestine from the stomach to the termination of the alimentary canal, in the excretory ducts of all the glands opening into the intestine, &c. Illustrations of this cylinder epithelium are given in the article DIGESTION. (3) *Spheroidal or glandular epithelium* is chiefly characteristic of the terminal recesses of secreting glands. (4) *Ciliated epithelium* consists of cells which bear on their free ends spontaneously moving filaments called *Cilia* (q.v.). (*b*) *Stratified epithelium* consists of cells arranged in many layers, and the individual cells present every variety of shape. As a rule the deepest cells are columnar, and those on the surface flattened and scale-like, but overlapping one another at their margins. It occurs on the anterior surface of the cornea of the eye, in the mouth, pharynx, œsophagus, &c., but its most extensive distribution is in the Epidermis (q.v.). (*c*) *Transitional epithelium* is intermediate between the forms already described, and may be grouped under the three terms columnar, ciliated, and scaly transitional, according to the kind of cell which is most superficial. In the case of the columnar and ciliated varieties there are smaller cells irregularly disposed between the fixed ends of the large ones, and this constitutes the only difference between these and the columnar and ciliated cells already described.

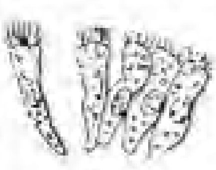


Fig. 4.
Ciliated cells from the finer bronchial tubes. Mag. 350 diam.

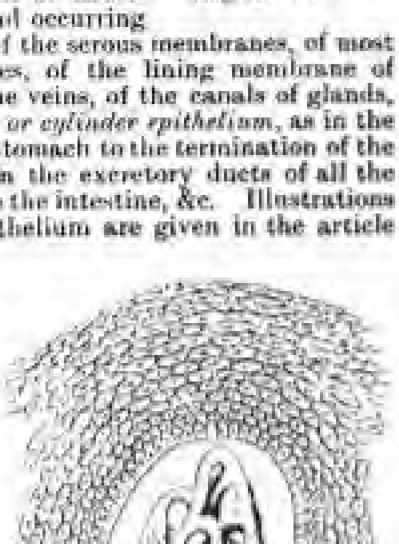


Fig. 5.
Stratified pavement epithelium investing a simple papilla (with blood-vessels in the interior) from the gums of a child. Mag. 250 diam.

Scaly transitional epithelium is found lining the urinary Bladder (q.v.) and ureters. The superficial cells are flattened scales when the bladder is distended, but cubical when empty. Moreover, the free surface of the cells is smooth, but on the deep aspect they are moulded over the rounded ends of the pear-shaped cells beneath. Irregular cells fill up the intervals between the tapering ends of the pyriform cells.

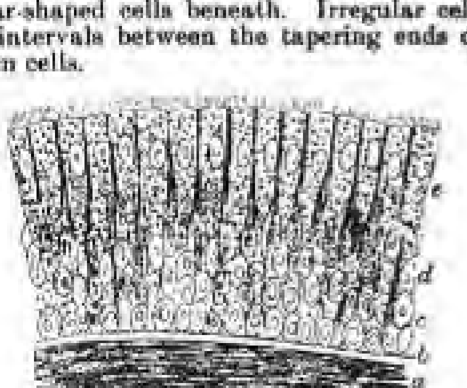


Fig. 6.
Ciliated epithelium from the trachea of a man. Mag. 350 diam. *a*, outermost part of the elastic longitudinal fibres; *b*, homogeneous outermost layer of the mucous membrane; *c*, deepest round cells; *d*, median long cells; *e*, outermost conical ciliated cells.

In all the varieties of epithelium the layer of external cells is being constantly disintegrated and replaced by the layer immediately beneath. The polygonal or pavement epithelium mainly acts like the epidermis, as a protecting medium to the soft parts beneath. The cylindrical epithelium additionally takes an active part in the process of secretion. Illustrations of the function of the cells forming this variety of epithelium are given in the articles CELL, CILIA, DIGESTION; and the subject will be further noticed under the head SECRETION.

Eprouvette is a machine for proving or testing the strength of gunpowder. The *gun* eprouvette does this by measuring the amount of recoil produced on a small gun swung like a pendulum; the *mortar* eprouvette by measuring the distance to which a ball is projected. A third pattern is shaped like a small pistol, with an extremely short barrel, closed by a flat plate connected with a strong spring. On firing, the plate is driven back to a distance indexed according to the strength of the powder.

Epsom Salt, or SULPHATE OF MAGNESIA, $MgSO_4 7H_2O$, was originally obtained by evaporating the waters of the springs at Epsom. It was soon found that sea-brine also contained large quantities, and the manufacture at Epsom was therefore given up. At present it is found native in various parts of America, and large quantities are manufactured near Genoa, by a chemical process, from a rock containing magnesia and sulphide of iron. In England, as well as in America, varieties of magnesian limestone are extensively treated with sulphuric acid for its production, with the result that the market is well supplied with this useful remedy.

Epsom salt forms small needle-like crystals, which have a bitter saline taste and neutral reaction. It is a well-known useful purgative medicine, acting as a refrigerant, and sometimes as a diuretic. Its disagreeable bitter taste may be relieved by the addition of a little sulphuric acid (as in Henry's solution) or syrup of lemon. It is given in doses of ¼ oz. to 1 oz. or more, but in every case it is of importance that plenty of water be drunk along with it (one or more tumblerfuls). See MAGNESIUM.

Ergot, a diseased condition of the ovary of grasses and sedges, due to the presence of species of Claviceps, a Pyrenomycete fungus (see FUNGI), of which the filamentous mycelium of the mould ramifies through the tissue of the flower, causing the outpouring of sugary sap, and bearing a multitude of spores, the ovary meantime becoming deformed and enlarged. In this state the mould was formerly described as a distinct species. This now withers on the surface, but the deeper mycelium within the ovary becomes denser and harder, forming the so-called sclerotium, and lies dormant until the grain is sown in early spring, when it bears globular heads which contain depressions or perithecia, containing the ascospores, which again recommence the cycle. The medicinal 'ergot of rye' is that formed by *Claviceps purpurea*. Producing rapid contraction of the uterus, it is often employed in midwifery; but its use in unskilled or unscrupulous hands is attended by the most serious risks. It has also been used in dysentery, epilepsy, whooping-cough, and as a styptic. The continued eating of bread made of ergotised rye produces a specific disease called *Ergotism*. This is a terrible form of poisoning, in which not only convulsions appear, but often also gangrene of the extremities, resulting in mutilation or death, even recovery from less serious doses being slow and difficult. Many dreadful epidemics in rye-consuming countries (as in Lorraine and Burgundy in 1816), the causes of which were not understood, are now supposed to have been due to ergotism. See also RAPHANIA.

Ergot of Rye.

Essence (Lat. *essentia*, from *esse*, 'to be'), as a philosophical term, the equivalent of the Greek *ousia*, was originally used in the same sense as *Substance* (q.v.). Later, substance came to be used for the undetermined substratum of a thing, essence for the qualities expressed in the definition of a thing; or, as Locke put it, 'Essence may be taken for the very being of a thing, whereby it is what it is.'—In Chemistry, and in popular parlance, essences are solutions of the essential oils in alcohol, and may be prepared (1) by adding rectified spirit to the odoriferous parts of plants, or to the essential oils, and distilling; or (2) simply by adding the essential oil to the rectified spirit, and agitating till a uniform mixture is obtained. Thus the essence of lemons is merely a solution of the volatile oil of lemons in rectified spirit. The term has, however, received a wider significance, and is applied to any liquid possessing the properties of the substance of which it professes to be the essence. Thus essences of coffee, beef, and rennet contain in a concentrated form the virtues of coffee, beef, and rennet, and in some circumstances may be substituted for them.

Ether, $(C_2H_5)_2O$, otherwise called ETHYLIC ETHER, VINIC ETHER, and SULPHURIC ETHER, is prepared from alcohol by the action of sulphuric acid at an elevated temperature. Alcohol is placed in a retort or still, and about an equal volume of sulphuric acid is added. Heat is at once developed by the mixing of the liquids, and on raising the temperature ether vapour passes over along with a proportion of alcohol. At the same time a stream of alcohol is allowed to pass into the still, and the heat is so regulated that a constant temperature of about 266° (130° C.) is maintained. When five volumes of alcohol in all have been added, the temperature is allowed to rise to 286° (141° C.), at which point impurities commence to pass over. The ether so obtained contains alcohol, sulphurous acid, and water, and these may be removed by treatment with solution of chloride of calcium, &c., and subsequent redistillation.

The chemical reactions which take place in this process are of great interest, and may be divided into two stages. (1) The sulphuric acid acts on alcohol, forming ethyl-sulphuric acid and water.

$$\underset{\text{Sulphuric Acid.}}{H_2SO_4} + \underset{\text{Alcohol.}}{C_2H_5OH} = \underset{\text{Ethyl-sulphuric Acid.}}{C_2H_5HSO_4} + \underset{\text{Water.}}{H_2O}$$

(2) This acid again is acted on by alcohol, with the re-formation of sulphuric acid and the production of ether.

$$\underset{\text{Ethyl-sulphuric Acid.}}{C_2H_5HSO_4} + \underset{\text{Alcohol.}}{C_2H_5OH} = \underset{\text{Ether.}}{(C_2H_5)_2O} + \underset{\text{Sulphuric Acid.}}{H_2SO_4}$$

From this it will be plain that the sulphuric acid is restored again, and is ready to attack alcohol anew, so as to form more ether. This process would go on indefinitely, were it not that the water liberated in the first reaction dilutes the sulphuric acid, and ultimately renders it too weak for further action.

Ether is a colourless, transparent, volatile liquid of great mobility and high refractive power, and possessing a fragrant odour and a fiery, passing to a cooling, taste. It has a specific gravity of ·720 at 60° (15·5° C.), and boils at 96° (35·6° C.), forming a vapour more than two and a half times as dense as air. When reduced to a temperature of − 24° (− 31° C.), ether freezes. It volatilises spontaneously when placed in an unconfined position, as in the palm of the hand, and vaporises so quickly as to produce intense cold. Indeed, when water is covered with ether, and the latter assisted in its evaporation by being blown upon, it escapes so readily as to reduce the temperature of the water to the freezing-point. It is very inflammable, burning with a yellow-white flame; and mixed with air or oxygen, it gives rise to a dangerous explosive mixture, and hence great care requires to be taken in its distillation to keep all lights and fires out of the room where the vapours are condensing. When ether is added to its own bulk of water, briskly agitated, and allowed to settle, the two liquids appear to separate again; but it is found that the ether has taken up one-eighth of its volume of the water, whilst the latter has dissolved the same quantity of ether. It is readily miscible with alcohol in all proportions. Ether is one of the best solvents for the oils and fats, and hence is employed in analysis for the solution and separation of the oils from other organic matters, as in the analysis of oil-cakes, &c. It is also a good solvent of iodine, sulphur, phosphorus, and of strychnine and other alkaloids, as well as of corrosive sublimate and other salts.

Ether enters into combination with many acids forming compound ethers possessing great fragrancy, such as

Acetic Ether......	$C_2H_5C_2H_3O_2$,	
Butyric Ether......	$C_2H_5C_4H_7O_2$,	Pine-apple Oil.
Pelargonic Ether...	$C_2H_5C_9H_{17}O_2$,	Essence of Quinces.

Œnanthic ether, on which the flavour and smell of wines, brandy, &c. so much depend, originally supposed to be a distinct ether, has been proved to be a mixture of various ethyl ethers, chiefly ethyl caprate.

Ether is useful in the preparation of freezing mixtures, the mixture of ether and solid carbonic acid giving rise to a very low temperature indeed. When inhaled by man and the lower animals, ether first produces stimulating and intoxicating effects, but afterwards it gives rise to drowsiness, accompanied by complete insensibility, which entitles ether to be regarded as an important anæsthetic agent; and, indeed, for some time it was the only agent used for producing Anæsthesia (q.v.) in operations, but in many places it has been entirely superseded by the employment of chloroform.

Ethiops, or ÆTHIOPS (Gr. *aithō*, 'I burn,' and *ops*, 'countenance'), is a term applied by the ancient chemists to certain oxides and sulphides of the metals which possessed a dull, dingy, or black appearance. Thus, *Ethiops Martialis* was the mixture of protoxide and peroxide of iron known as the black oxide.

Ethyl, $(C_2H_5)_2$, is a colourless, inflammable gas, obtained by the action of iodide of ethyl, C_2H_5I, on granulated zinc. It possesses an agreeable odour, is insoluble in water, but soluble in alcohol. It is not, however, on its own account that ethyl is of importance, but because it is the starting-point of an important series of organic compounds known as the *ethyl series*. In all of these the group CH_3-CH_2 or C_2H_5 is present, and acts as if it were an atom of some elementary substance—*e.g.* potassium. Thus we have

Potassium,	K;	Ethyl,	C_2H_5
A molecule of Potassium,	K_2;	A molecule of Ethyl,	$(C_2H_5)_2$
Potassium Iodide,	KI;	Ethyl Iodide,	C_2H_5I
Potassium Oxide,	K_2O;	Ethyl Oxide or Ether	$(C_2H_5)_2O$
Caustic Potash,	KOH;	Ethyl Hydrate or Alcohol,	C_2H_5OH.

In these we see that the group of atoms, C_2H_5, always enters into combination as if it were indivisible, and it is usual to call this group ethyl, and to reserve the term diethyl for the compound $(C_2H_5)_2$ described above. Ethyl, C_2H_5, is only hypothetical, and does not exist in the free state, while diethyl, $(C_2H_5)_2$, is an actual gas. See ALCOHOL, BASE, and ETHER.

Ethylamine, $NH_2C_2H_5$, is a substance resembling ordinary ammonia in its odour and many of its properties. It is found in coal-tar, in the oil obtained during the destructive distillation of bones, in the gases evolved during putrefaction, and may be produced by complicated chemical processes. Ethylamine has been called an artificial alkaloid (see ALKALOID), because it is regarded from a chemical point of view as ammonia, in which one atom of hydrogen is replaced by the group Ethyl (q.v.).

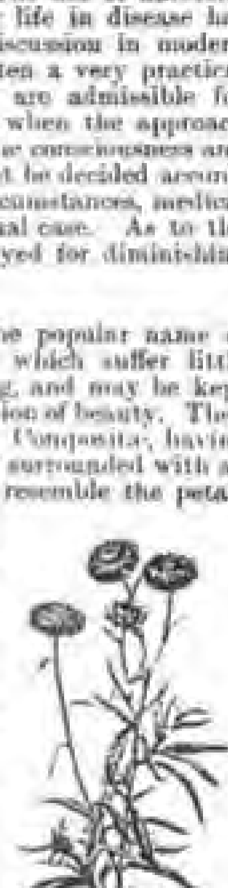
Euchlorine is a very explosive green-coloured gas, possessing bleaching properties, and is prepared by the action of strong hydrochloric acid on chlorate of potash. It is dangerously explosive by heat, and its composition is still a matter of discussion. It is variously supposed to contain chloric and chlorous acids, as well as free chlorine and oxygen.

Euphorbia, OIL OF, or OIL OF CAPER SPURGE, an extremely acrid fixed oil, obtained by expression, or by the aid of alcohol or ether, from the seeds of the Caper Spurge (*Euphorbia lathyris*), a plant common in many parts of Europe, and in some places in America and Britain (see SPURGE). Oil of euphorbia has much resemblance to croton-oil in its properties, although less powerful, and is sometimes used as a substitute for it, in doses of from three to ten drops. It is good for use only when recently extracted.

Caper Spurge (*Euphorbia lathyris*).

Euthana'sia (Gr.), an easy death, or a painless method of putting to death. The use of narcotics or other means for shortening life in disease has never become a subject of discussion in modern civilised countries, but it is often a very practical question how far such means are admissible for soothing the last hours of life, when the approach of death does not itself dull the consciousness and the sensibility to pain. It must be decided according to all the surrounding circumstances, medical and otherwise, in each individual case. As to the medical treatment to be employed for diminishing the sufferings of the dying.

Everlasting Flower, the popular name of certain plants, the flowers of which suffer little change of appearance in drying, and may be kept for years without much diminution of beauty. They are plants chiefly of the order Compositæ, having their flowers (heads of flowers) surrounded with an involucre, the scales of which resemble the petals of a corolla, but are rigid, membranous, and contain little moisture. Some species of Cudweed (q.v.) (Gnaphalium) are often called everlasting flowers, and the other plants which bear the name belong to nearly allied genera, but particularly to Helichrysum, Rhodanthe, and Acroclinium, which are mostly annuals and natives of Africa and Australia. *Helichrysum arenarium* is frequent on dry, sandy soils in many parts of Europe and the central latitudes of Asia. It is covered with a gray felted down, and has yellow flowers, which, when rubbed, emit a faint aromatic odour. It is often worn on the continent of Europe as an ornament in the hat, particularly by wagoners. *H. angustifolium* and *H. Stæchas*—shrubby species, natives of the south of Europe—have larger yellow flowers. Some of the species have a powerful and pleasant aromatic odour. Several kinds of everlasting flowers are frequently to be seen in our gardens; others, such as Phænocoma and Aphlexis, natives of the Cape of Good Hope, are of shrubby habit, and choice and beautiful greenhouse plants. As an instance of everlasting flowers in other orders than Compositæ may be mentioned the genus Statice; the coloured calyx in nearly all the numerous species of which it is composed is dry, membranous, and very persistent. The French call everlastings *Immortelles*, and often weave them into circular wreaths, which are placed beside recent graves, as emblems of immortality or of loving memory. A very extensive trade is now carried on by France, Germany, and Italy in growing and preserving everlasting flowers for exporting to Britain and America.



Everlasting Flower (*Helichrysum bracteatum*).

Expectorants (Lat. *ex*, 'out of,' and *pectus*, 'the breast'), medicines given to carry off the expectorations—the mucus and other secretions of the air-tubes. The principal expectorants are antimony, ammonia, squill, ipecacuanha, senega, balsam of tolu, lobelia, gum ammoniac, asafœtida, galbanum, &c. The examination of the expectoration is of great value in the diagnosis of diseases of the chest (see BRONCHITIS, PNEUMONIA, CONSUMPTION). The word 'expectoration' has come by an abuse to be regarded as a mere elegant synonym for spitting. See SALIVA.

Extractive Matter is the term applied to the soluble portions of any drug. The substances extracted from the same drug may vary according as the solvent is water, alcohol, ether, &c.; but, so long as the originally insoluble portions are not rendered soluble by the chemical action of the solvent, the term extractive matter is applicable to them.

Extracts, in a technical sense, are medicinal preparations of vegetable principles, got either by extracting these from the plants by means of a solvent or menstruum, and then evaporating the liquid down to about the consistency of honey, or by expressing the juice of the plants and evaporating; this last is properly *inspissated juice*. Extracts, therefore, contain only those vegetable principles that are either held in solution in the juices of the plants themselves, or are soluble in the liquid employed in extracting them, and at the same time are not so volatile as to be lost during evaporation. Now, as many extractive matters are more or less volatile, it makes a great difference whether the operation is conducted at a low or at a high temperature. Besides the loss of volatile constituents by prolonged or excessive heating, extracts become more or less changed and inert owing to the readiness with which vegetable principles are destroyed when exposed to heat and air. On this account it is usual to avoid evaporation as much as possible, and, where this is impracticable, evaporation *in vacuo* is resorted to. Extracts are called *watery* or *alcoholic* according as the menstruum employed is water or alcohol. Ether is also used in extracting. Different plants, of course, afford different extracts, some being of the nature of bitters, others being used as pigments, tannin, &c.

Liquid extracts are those which are not evaporated so far as to form a paste, and it is usual to make them of such a strength that one fluid ounce contains the active ingredients of one ounce by weight of the drug.

EXTRACT OF MEAT is obtained by acting upon chopped meat by cold water, and gradually heating, when about one-eighth of the weight of the meat dissolves out, leaving an almost tasteless insoluble fibrin. The extract of meat contains the salts and savoury constituents of the meat, and is a light and stimulating article of food (see BEEF-TEA, and BROTH). It may be concentrated into small bulk, and, when desired, may be afterwards treated with water; being heated, it forms an agreeable light soup, though rather stimulating than nutritious. Of this nature is the well-known Liebig's Extract. In order to impart to extract of meat a nutritive as well as stimulant value, the fibrin is sometimes dried and powdered, and, when then incorporated with the extract itself, a product is obtained which represents the original meat in a readily digested form.

Eye. In this article we shall consider: (1) The structure of the human eyeball, and of certain accessory parts or appendages which serve to protect that organ, and are essential to the due performance of its functions. (2) The most striking modifications which this organ presents in some of the lower animals. (3) The eye considered as an optical instrument. (4) The action of the retina. (5) The movements of the eyeballs, and binocular vision.

(1) The *globe of the eye* is placed in the anterior part of the cavity of the orbit, in which it is held in position by its connection with the optic nerve posteriorly, by the muscles which surround it, and by the eyelids in front. It is further supported behind and on the sides by a quantity of loose fat, which fills up all the interstices of the orbit, and facilitates the various movements of which the eye is capable.

The form of the eyeball is nearly spherical; but on viewing the organ in profile we see that it is composed of segments of two spheres of different diameters. Of these, the anterior, formed by the transparent cornea, is more curved, and therefore more prominent. The horizontal transverse diameter

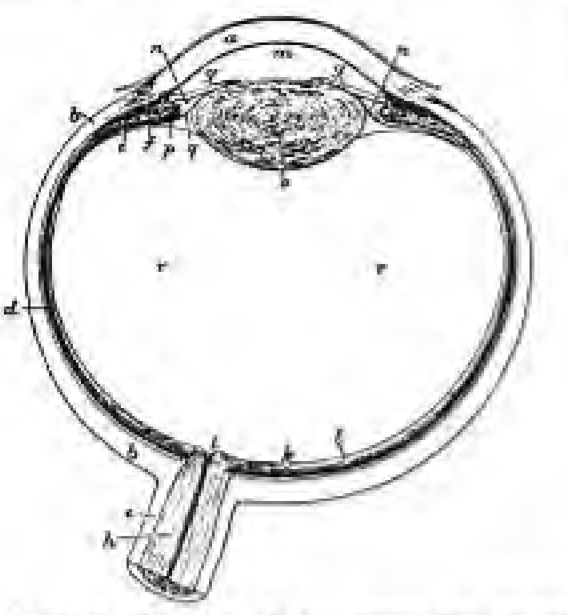


Fig. 1.—View of lower half of right Human Eye, divided horizontally:

a, cornea; *b*, sclerotic; *c*, sheath of optic nerve passing into sclerotic; *d*, choroid; *e*, ciliary muscle; *f*, ciliary process; *g*, *g*, iris; *h*, optic nerve with artery in centre; *i*, passage of nerve into retina, called optic disc or papilla; *k*, fovea centralis; *l*, retina; *m*, anterior chamber of aqueous humour; *n*, posterior chamber of aqueous humour; *o*, crystalline lens; *p*, zonule of Zinn; *q*, suspensory ligament of lens; *r*, vitreous humour.

is almost exactly an inch; the antero-posterior and vertical each about $\frac{1}{20}$ less. The radius of the posterior or sclerotic segment is about half, and that of the anterior segment about three-tenths of an inch.

When the eyes are in a state of repose, their antero-posterior axes are parallel; the optic nerves, on the other hand, diverge considerably from their commissure within the cavity of the skull to the point where they enter the globe; consequently their direction does not coincide with that of the eye. Each nerve enters the back of the globe at a distance of about one-eighth of an inch on the inner side of the antero-posterior axis of the eye.

The eyeball is composed of three concentric membranes, and of certain transparent structures, which are inclosed within them, and which, together with the cornea, transmit and refract the rays of light which enter the eye.

The outer (fibrous or protective) membrane consists of the sclerotic and cornea; the middle (vascular or nutrient) of the choroid and iris; the inner (nervous or percipient) of the retina. The transparent contents are (from before backwards) aqueous humour, crystalline lens, and vitreous humour. We shall consider these structures in order.

The *sclerotic* (from *skleros*, 'hard'), or 'white of the eye,' is a strong, dense, fibrous structure, covering about five-sixths of the eyeball, and continuous, anteriorly, with the cornea. Posteriorly, it is perforated by the optic nerve, and it is there continuous with the sheath which that nerve derives from the dura mater, the fibrous investment of the brain and spinal cord. Near the entrance of the nerve, its thickness is about $\frac{1}{25}$th of an inch; from this it diminishes to about $\frac{1}{50}$th; but in front it again becomes thicker, from the tendinous insertions of the straight muscles which blend with it.

The *cornea* (so called from its horny appearance) is a transparent structure, continuous with the sclerotic, from which it differs more in appearance than in texture, and completing the fibrous tunic of the eye anteriorly. Its circumference is overlaid by the free edge of the sclerotic, as 'a watch-glass by the edge of the groove into which it is received.' Its thickness is from $\frac{1}{25}$th to $\frac{1}{20}$th of an inch. It is covered in front by a layer of conjunctival epithelium, which is exquisitely sensitive.

The cornea, in consequence of its greater convexity, projects beyond the line of the sclerotic; the degree of convexity, however, varies slightly in different persons, and at different periods of life. It is so strong as to be able to resist a force capable of rupturing the sclerotic. The fibrous coat, by its great strength and comparatively unyielding structure, maintains the inclosed parts in their proper form, and serves to protect them from external injuries.

The *choroid coat* is a dark-coloured vascular membrane, which is brought into view on the removal of the sclerotic. Its outer surface, which is nearly black, is loosely connected with the sclerotic by connective tissue, in which are contained certain nerves and vessels—termed the ciliary nerves and vessels—some of which go forward to the iris. Its inner surface is smooth and dark-coloured. In front, it terminates in the *ciliary processes* (figs. 1 and 3), which consist of about sixty or seventy radiating folds or thickenings of the membrane, each of them terminated by a small free interior extremity, and lodged in a corresponding fold in the suspensory ligament of the lens. In other parts, it is covered by the

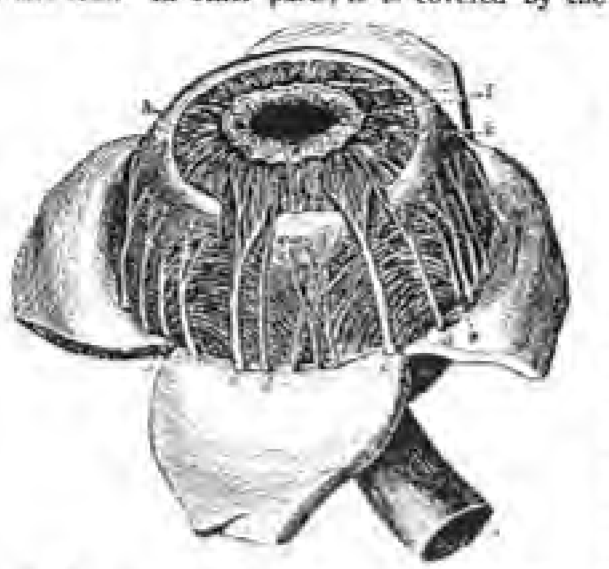


Fig. 2.—Choroid and Iris, exposed by turning aside the sclerotic:

a, *a*, ciliary nerves going to be distributed to iris; *d*, *d*, smaller ciliary nerves; *e*, *e*, veins known as vasa vorticosa; *h*, ciliary muscle; *k*, *l*, converging fibres of iris; *n*, optic nerve.

hexagonal pigment-cells of the retina. The choroid is composed of minute ramifications of vessels—especially of veins, which, from their whirl-like arrangement, are termed *vasa vorticosa*—of connective tissue, and of large branching pigment-cells. Between the sclerotic and choroid at its anterior part lies a small but important structure, the *ciliary muscle*, which arises from the inner surface of the sclerotic near the cornea, and passes backwards to be inserted into the choroid opposite the ciliary processes.

The *iris* may be regarded as a process of the choroid, with which it is continuous, although there are differences of structure in the two membranes. It is a thin flat membranous curtain, hanging nearly vertically in the aqueous humour in front of the lens, and perforated by the pupil for the transmission of light. Its anterior surface is variously coloured, and covered by fine irregularly-radiating projections; its posterior surface is smooth, and covered by a

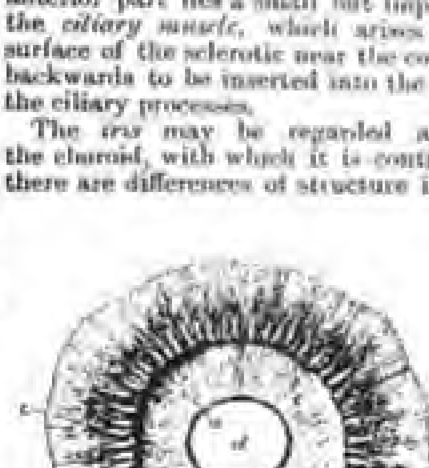


Fig. 3.—Iris and Ciliary Processes from behind:

a, posterior surface of the iris, with the sphincter muscle of the pupil; *b*, anterior part of the choroid coat; *c*, one of the ciliary processes, of which about seventy are represented; *d*, the pupil.

uniform layer of dark pigment, continuous with the pigment-cells of the retina. The posterior surface near the pupil is in contact with the anterior capsule of the lens. It divides the space between the cornea and the lens into an anterior (the larger) and a posterior (the smaller) chamber, these two chambers freely communicating through the pupil (see fig. 1). The outer and larger border is attached all round near the line of junction of the sclerotic and cornea, to the cornea, choroid, and ciliary muscle, while the inner edge forms the boundary of the pupil, which is nearly circular, lies a little to the side of the centre of the iris, and varies in size according to the action of the muscular fibres of the iris, so as to admit more or less light into the interior of the eyeball; its diameter varying, under these circumstances, from about $\frac{1}{3}$d to $\frac{1}{24}$th of an inch. It is muscular in its structure, one set of fibres being arranged circularly round the pupil, and, when necessary, effecting its contraction, while another set lie in a radiating direction from within outwards, and by their action dilate the pupil. These fibres are of the unstriped or involuntary variety. The nerves which are concerned in these movements will be presently noticed. The iris is richly supplied with blood-vessels; and pigment-cells like those of the choroid are scattered through its substance.

The varieties of colour in the eyes of different individuals, and of different kinds of animals, mainly depend upon the colour and amount of the pigment in these cells. In blue eyes, this pigment is scanty or absent, and the colour is due to the dark pigment of the posterior surface partly seen through the vascular membrane; in brown and black eyes, it is abundant, and is the cause of the colour. In albinos, this pigment is absent from iris, retina, and choroid, and hence their eyes have a pink appearance, which is due to the unconcealed blood in the capillaries of the choroid and iris.

Within the choroid is the *retina*, which, although continuous with the optic nerve—of which it is usually regarded as a cuplike expansion—differs very materially from it in structure. Before noticing the elaborate composition of this part of the eye, which has only been revealed by microscopical investigation, we shall briefly mention those points regarding it which can be established by ordinary examination. It is a delicate semi-transparent sheet of nervous matter, lying immediately behind the vitreous humour, and extending from the optic nerve nearly as far as the lens. On examining the concave inner surface of the retina at the back of the eye (see fig. 4), we observe, directly in a line with the axis of the globe, a circular yellow spot (*macula lutea*), of about $\frac{1}{24}$th of an inch in diameter, called, after its discoverer, the *yellow spot of Sommering*, with a depression in its centre, the *fovea centralis*. About $\frac{1}{8}$th of an inch internal to this is the entrance of the optic nerve, called the *optic disc* or *papilla*, from which the central artery and vein of the retina may be seen branching as they pass to their distribution.

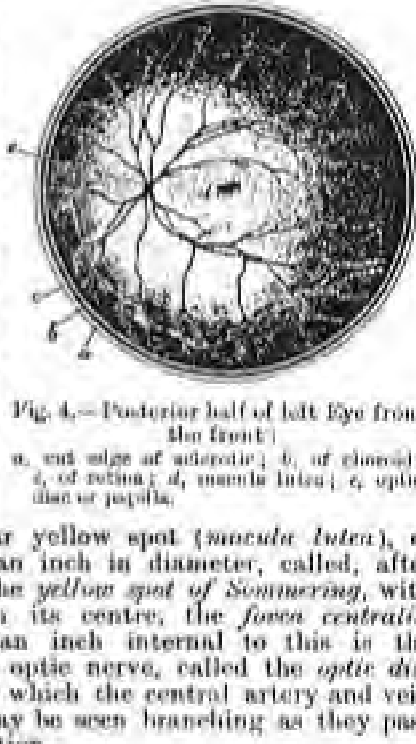


Fig. 4.—Posterior half of left Eye from the front:

a, cut edge of sclerotic; *b*, of choroid; *c*, of retina; *d*, macula lutea; *e*, optic disc or papilla.

The structure of the retina, as revealed by the microscope, is in the highest degree remarkable (see fig. 5). Although its greatest thickness (at the entrance of the optic nerve) is only about $\frac{1}{80}$th of an inch, and as it extends anteriorly, it soon diminishes to $\frac{1}{120}$th of an inch, the following layers from without inwards can be distinguished in most parts of it: (*a*) The pigmentary layer, consisting of a single layer of flat hexagonal cells, regularly arranged; its outer surface closely connected with the choroid, its inner in contact with the ex-

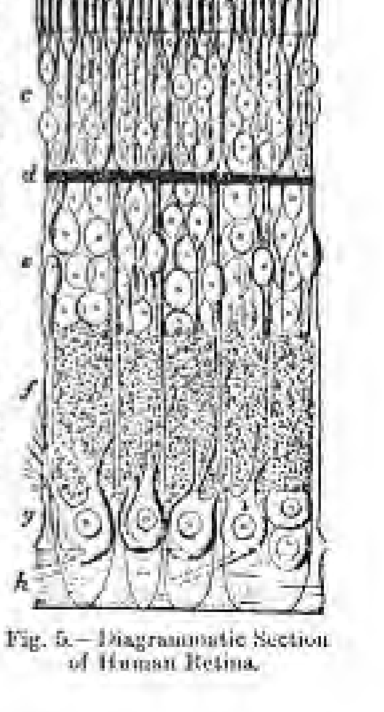


Fig. 5.—Diagrammatic Section of Human Retina.

tremities of the rods and cones. Though its development shows that it really belongs to the retina, its mechanical connection with the choroid is firmer; and to this it adheres when the retina is stripped off. (*b*) The layer of rods and cones, frequently termed, from its discoverer, the *membrane of Jacob*; (*c*) outer granular layer; (*d*) outer molecular; (*e*) inner granular; (*f*) inner molecular; (*g*) layer of nerve-cells; (*h*) layer of nerve-fibres, in which the blood-vessels lie.

The layer of rods and cones, the portion of the eye which receives the impressions of light, deserves special attention. The rods are thinner but longer than the cones, and in most parts of the retina far more numerous. At the yellow spot, however, only cones are found. Each rod or cone consists of a thicker inner portion, connected with the outer granular layer, and ultimately with the optic nerve by a fine fibril; and an outer thinner part, directed towards and connected with the pigmentary layer. The percipient elements are thus directed away from, not towards the light. 'In fact, we do not look outwards at the actual object, but we see the object as reflected from the base of our own eye.' Of the cones there are several, of the rods many millions in each human eye, and they are closely packed together over the whole extent of the retina.

It now remains for us to describe the *transparent media* which occupy the interior of the globe, and through which the rays of light must pass before they can reach the retina, and form on it the images of external objects. We shall consider them in the order in which the rays of light strike them.

Immediately behind the transparent cornea is the *aqueous humour*, which fills up the anterior and posterior chambers which lie between the cornea and the lens. As its name implies, it is very nearly pure water, with a mere trace of albumen and chloride of sodium. It is believed to be secreted by the choroid and to pass forward from it through minute lymphatic channels.

The *crystalline lens* lies opposite to and behind the pupil, in contact with the inner part of the iris, and its posterior surface is received into a corresponding depression on the forepart of the vitreous humour (see fig. 1). In form, it is a double-convex lens, with surfaces of unequal curvature, the posterior being the most convex. It is inclosed in a transparent capsule, of which the part covering the anterior surface is nearly four times thicker than that at the posterior aspect. The microscopic examination of the substance or body of the lens reveals a structure of wonderful beauty. Its whole mass is composed of extremely minute elongated ribbon-like structures, commonly called the *fibres of the lens*. These fibres are arranged side by side in lamellæ, of which many hundred exist in every lens, and which are so placed as to give to the anterior and posterior surfaces the appearance of a central star, with meridian lines. The lens gradually increases in density, and at the same time in refracting power, towards the centre; by this means, the refracting power is made greater than it would be even if the lens had throughout the same index of refraction as the nucleus. (According to the latest measurements, the index of refraction of the outer layer is 1·393; of the nucleus, 1·431; the total refractive power corresponds to that of a homogeneous body of the same size and shape with index 1·448.) This arrangement besides corrects to a certain extent the spherical aberration of the eye. According to Berzelius, the lens contains 58 per cent. of water, 36 of albumen, with minute quantities of salts, membrane, &c. In consequence of the albumen, it becomes hard and opaque on boiling, as we familiarly see in the case of the eyes of boiled fish. In the adult, its diameter transversely is about ⅓d, and its thickness antero-posteriorly about ⅙th of an inch; and it weighs three or four grains. The lens is held in position by the *suspensory ligament* of the lens and *zonule of Zinn*, a fine transparent fibrous structure, attached outwardly to the choroid between the ciliary processes, and passing inwards to blend with the anterior and posterior capsule of the lens near its margin (see fig. 1).

The *vitreous humour* lies in the concavity of the retina, and occupies about four-fifths of the eye posteriorly. Its form is shown in fig. 1. It is inclosed, except in front, in the hyaloid membrane, which blends anteriorly with the zonule of Zinn; and its anterior surface is in contact with the posterior capsule of the lens. It is quite transparent, and of a soft gelatinous consistence. Its outer part at least is laminated, like the coats of an onion. But the exact arrangement of the framework which gives it its consistence has not been determined. Between the anterior border of the retina and the border of the lens, we have a series of radiating folds or plaitings termed the *ciliary processes of the vitreous body*, into which the *ciliary processes of the choroid* dovetail. The vitreous humour contains, according to Berzelius, 98·4 per cent. of water with a trace of albumen and salts, and hence, as might be expected, its refractive index is almost identical with that of water.

The appendages of the eye now claim our notice. The most important of these appendages are the *muscles within the orbit*, the *eyelids*, the *lachrymal apparatus*, and the *conjunctiva*, to which (although less important) we may add the *eyebrows*.

The *muscles* by which the eye is moved are four straight (or *recti*) muscles, and two oblique (the superior and inferior). The former arise from the margin of the optic foramen at the apex of the orbit, and are inserted into the sclerotic near the cornea, above, below, and on either side. The superior oblique arises with the straight muscles; but after running to the upper edge of the orbit, has its

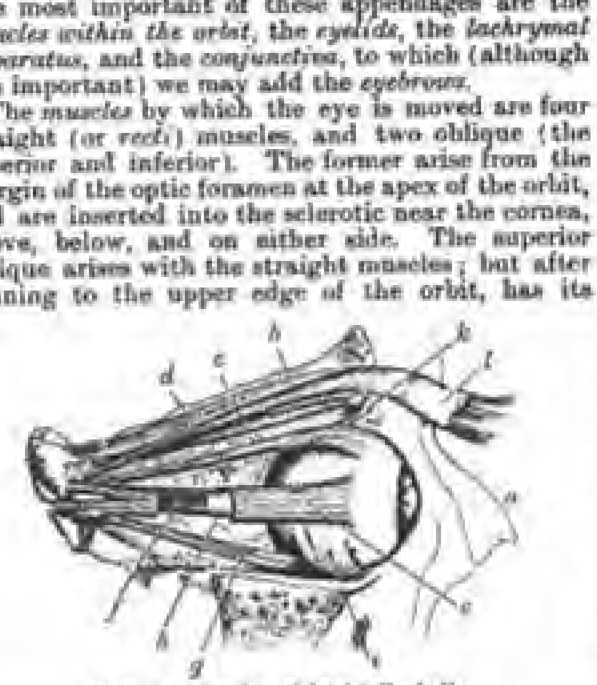


Fig. 6.—Muscles of Right Eyeball:

The external rectus muscle divided to show the optic nerve, which has also been cut to show the internal rectus muscle.

a, nasal bone; *b*, levator palpebræ superioris; *c*, superior oblique; *d*, superior rectus; *e*, external rectus; *f*, internal rectus; *g*, inferior rectus; *h*, optic nerve; *i*, inferior oblique; *k*, pulley; *l*, tarsal cartilage.

direction changed by a pulley, and proceeds backwards, outwards, and downwards (see fig. 6). The inferior oblique arises from the lower part of the orbit, and passes backwards, outwards, and upwards. The action of the straight muscles is sufficiently obvious from their direction: when acting collectively, they fix and retract the eye; and when acting singly, they turn it towards their respective sides. The oblique muscles antagonise the recti, and draw the eye forwards; the superior, acting above, directs the front of the eye downwards and outwards, and the inferior upwards and inwards. By the duly associated action of these muscles, the eye is enabled to move (within definite limits) in every direction.

The *eyelids* are two thin movable folds placed in front of the eye, to shield it from too strong light, and to protect its anterior surface. They are composed of (1) skin, with a layer of muscle (part of the *orbicularis*, see below) closely adherent to it; (2) of a thin plate of fibro-cartilage, termed the *tarsal cartilage*, the inner surface of which is grooved by thirty or forty parallel vertical lines, in which the Meibomian glands are imbedded; and (3) of a layer of mucous membrane (*conjunctiva*), continuous, as we shall presently see, with that which lines the nostrils, and joining the skin at the margin of the lids, in which the eyelashes (*cilia*) are arranged in two or more rows. The upper lid is much the larger; and to the posterior border of its cartilage a special muscle is attached, termed the *levator palpebræ superioris*, whose object is to elevate the lid, and thus open the eye; while there is another muscle, the *orbicularis palpebrarum*, which surrounds the orbit and eyelids, and by its contraction closes the eye. The Meibomian glands secrete a sebaceous matter, which facilitates the free motion of the lids, and prevents their adhesion. The eyelashes intercept the entrance of foreign particles directed against the eye, and assist in shading that organ from an excess of light.

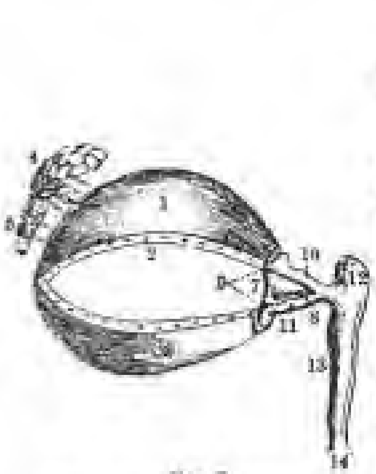


Fig. 7.
The Appendages of the Eye:
1, the cartilage of the upper eyelid; 2, its lower border, showing the openings of the Meibomian glands; 3, the cartilage of the lower eyelid, also showing on its border the openings of the Meibomian glands; 4, 5, the lachrymal gland; 6, its ducts; 7, the plica semilunaris; 8, the caruncula lachrymalis; 9, the puncta lachrymalia, opening into the lachrymal canals; 10, 11, the superior and inferior lachrymal canals; 12, the lachrymal sac; 13, the nasal duct, terminating at 14 in the lower meatus of the nose.

The *lachrymal apparatus* consists of the lachrymal gland, by which the tears are secreted; two canals, into which the tears are received near the inner angle of the eye; the sac, into which these canals open; and the duct, through which the tears pass from the sac into the nose. The gland is an oblong body, about the size of a small almond, lying in a depression in the upper and outer part of the orbit. The fluid secreted by it reaches the surface of the eye by twelve or fourteen ducts, which open on the conjunctiva at its upper and outer part. The constant motion of the upper eyelid induces a continuous gentle current of tears over the surface, which carry away any foreign particle that may have been deposited on it. The fluid then passes through two small openings, termed the *puncta lachrymalia* (see 9 in fig. 7), into the canals; whence its further course into the lower portion of the nose is sufficiently obvious from the figure. The conjunctiva (or mucous coat) which covers the front of the eyeball, and lines the inner surface of the lids, passes down and lines the canals, sac, and duct; and is thus seen to be continuous with the nasal mucous membrane, of which it may be regarded as an offshoot or digital prolongation. See MUCOUS MEMBRANES.

We shall conclude this sketch of the anatomy of the human eye by a brief notice of the *nerves* going to this organ and its appendages. Into each orbit there enters a nerve of *special sense*—viz. the optic nerve; a nerve of *ordinary sensation*—viz. the ophthalmic branch of the fifth nerve; and certain nerves of *motion* going to the muscular tissues, and regulating the movements of the various parts—viz. the third, fourth, and sixth nerves.

As the optic tracts from which the *optic nerves* originate are noticed in the article BRAIN, we shall merely trace these nerves from their *chiasma* or commissure forwards. This commissure results from the junction of the optic tracts of the two sides; and it is especially remarkable for the fact that it presents a partial decussation of the nervous fibres; the central fibres of each tract passing into the nerve of the *opposite* side, and crossing the corresponding fibres of the other tract, while the outermost fibres, which are much fewer in number than the central ones, pass to the optic nerve of the *same* side. In front of the commissure, the nerves enter the optic foramen at the apex of the orbit, receive a sheath or investment from the *dura mater*, acquire increased firmness, and finally terminate in the retina. The peculiar mode of termination of the optic nerves in the cuplike expansion of the retina, the impairment or loss of vision which follows any morbid affection of them, and the constant relation in size which is observed in comparative anatomy between them and the organs of vision, afford sufficient evidence that they are the proper conductors of visual impressions to the sensorium.

The first or ophthalmic division of the fifth or trifacial nerve sends branches to the eyeball (ciliary nerves), to the skin of the eyelids, and to the conjunctiva. That it is the nerve of ordinary sensation of the eye is sufficiently obvious from the following facts: (1) That in disease of this nerve in the human subject, it is not uncommon to find the surface of the eyeball totally insensible to every kind of stimulus (particles of dust, pungent vapours, &c.); and (2) that if the nerve be divided in the cranium (in one of the lower animals), similar insensibility results.

The most important of the nerves of motion of the eye is the third nerve, or *motor oculi.* It supplies with motor power the elevator of the upper eyelid, and all the muscles of the globe, except the superior oblique and the external straight muscle, and, in addition to this, it sends filaments to the iris and ciliary muscle within the eye. The application of an irritant (in vivisection experiments) to its trunk induces convulsive contraction of the principal muscles of the ball and of the iris; while paralysis or division of the trunk occasions an external squint, with palsy of the upper eyelid and fixed dilatation of the pupil. The squint is caused by the action of the external straight and the superior oblique muscles, while the other muscles are paralysed by the operation. The normal motor action of the nerve upon the iris, in causing contraction of the pupil, is excited through the optic nerve, and affords a good illustration of *Reflex Action* (q.v.); the stimulus of light falling upon the retina, and, through it, exciting that portion of the brain from which the third nerve takes its origin. This nerve clearly exerts a double influence in relation to vision: (1) it mainly controls the movements of the eyeball and the upper eyelid; and (2) from its connection with the muscular structures in the interior, it regulates the amount of light that can enter the pupil, and the adjustment of the eye to various distances. The fourth nerve supplies the superior oblique muscle with motor power, while the sixth nerve similarly regulates the movements of the external straight muscle—the only two muscles in the orbit which are not supplied by the third pair. Although not entitled to be termed a nerve of the orbit, the facial nerve deserves mention as sending a motor branch to the *orbicularis* muscle, by which the eyelids are closed.

(2) *Comparative Anatomy of the Eye.*—In *mammals,* the structure of the eye is usually almost identical with that of man. The organ is, however, occasionally modified, so as to meet the peculiar wants of the animal. Thus, in the Cetacea, and in some amphibious Carnivora that catch their prey in the water, the shape of the lens is nearly spherical, as in fishes, and there is a similar thickening of the posterior part of the sclerotic, so as to thrust the retina sufficiently forward to receive the image formed by such a lens. (See the subsequent remarks on the eyes of fishes.) Again, instead of the dark-brown or black pigment which lines the human choroid, a pigment of a brilliant metallic lustre is secreted in many of the mammalia, forming the so-called *tapetum lucidum* at the bottom of the eyeball, which seems (according to Bowman) to act as a concave reflector, causing the rays of light to traverse the retina a second time, and thus probably increasing the visual power, particularly where only a feeble light is admitted to the eye. The pupil, moreover, varies in form, being transversely oblong in the Ruminants and many other Herbivora, and vertically oblong in the smaller genera of Cats. These shapes are apparently connected with the positions in which the different animals look for their food. Lastly, in some mammals (e.g. the horse) there is a rudimentary third eyelid corresponding to the *membrana nictitans* of birds.

In *birds,* the eye, though presenting the same general composition as in man, differs from the mammalian eye in several important points. From our knowledge of the habits of birds (especially birds of prey), we should naturally expect that in their rapid movements they would be able readily to alter the focus between the extremes of long and short sighted vision, and the modifications we shall now proceed to notice clearly have this object in view.

In reference to fig. 8, which represents a section of the eye of the owl, we see (1) that the shape of the organ is not spherical, as in mammals, nor flattened anteriorly, as in fishes and aquatic reptiles, but that the cornea is very prominent, and the antero-posterior diameter lengthened; the consequence of this arrangement being to allow room for a large quantity of aqueous humour, and to increase the distance between the lens and the posterior part of the retina, and thus to produce a greater convergence of the rays of light, by which the animal is enabled to discern near objects. In order to retain this elongated form, we find a series of bony plates, forming a broad zone, extending backwards from the margin of the cornea, and lying imbedded in the sclerotic. The edges of the pieces forming this bony zone overlap each other, and are slightly movable, and hence, when they are compressed by the action of the muscles of the ball, there is protrusion of the aqueous humour and of the cornea, adapting the eye for near vision; while relaxation of the muscles induces a corresponding recession of the humour and flattening of the cornea, and fits the eye for distant vision. The focal distance is further regulated by a highly vascular organ called the *marsupium,* or *pecten,* which is lodged in the posterior part of the vitreous humour (fig. 8, *a*). It is attached to the optic nerve at the point where it expands into the retina, and seems to be endowed with a power of dilatation and contraction; as it enlarges, from distension of its blood-vessels, it causes the vitreous humour to push the lens forwards, while, as it collapses, the lens falls backwards again towards the retina.

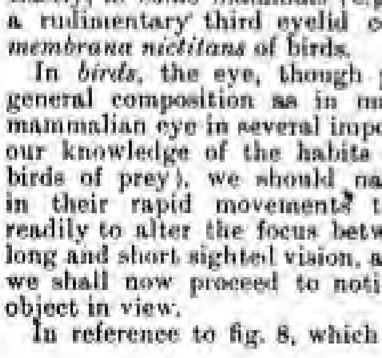


Fig. 8.—Eye of Bird.

In addition to an upper and lower eyelid, birds have an elastic fold of conjunctiva, which, in a state of repose, lies in the inner angle of the eye, but is movable by two distinct muscles, which draw it over the cornea. It is termed the *membrana nictitans;* it is to a certain degree transparent, for (according to Cuvier) birds sometimes look through it, as, for example, the eagle when looking at the sun. The lachrymal gland is situated as in mammals, but there is here a second gland, the *glandula Harderi,* which yields a lubricating secretion.

There are no very special peculiarities in the eyes of *reptiles,* and we therefore proceed to notice the most remarkable points presented by the eye in *fishes.* From the comparatively great density of the medium (water) through which the rays of light pass before they impinge upon the transparent structure of the eye of the fish, it is obvious that this organ must act as a very powerful refractive apparatus. The main peculiarity in the eye of the fish is the size, extreme density, and spherical shape of the lens, which give it such an extraordinary magnifying power that it has been employed as a simple microscope. See Brewster's *Treatise on the Microscope,* p. 31. But its focus being shortened in proportion as its power is increased, it is necessary that the retina should be brought near its posterior surface. For this purpose the eyeball is flattened by diminishing the quantity of vitreous humour; and this flattened form is maintained by the existence of two cartilaginous plates in the tissue of the sclerotic, which in some of the larger fishes is actually converted into a bony cup. The aqueous humour, as the cornea has here hardly any refractive power and is also flattened, is barely sufficient to allow the free suspension of the iris. The pupil is very large, so as to take in as much light as possible, but is generally motionless. Their eyes being constantly washed by the water in which they live, no lachrymal apparatus is necessary, nor does any exist; and the same remark applies to the *cetacea* amongst the mammals. We thus see that throughout the sub-kingdom of the *vertebrata* the eye is constructed according to one general scheme, with modifications to suit the mode of life of individual classes.

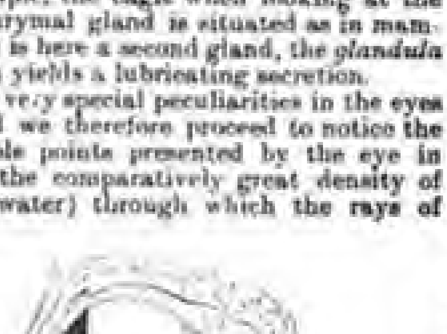


Fig. 9.—Eye of Fish.

There is another organ present in most vertebrate animals which seems, from recent investigations, to represent an eye, though it is very doubtful whether it has the power of sight in any living animal. This is represented in mammals and birds by the pineal gland (see BRAIN); but in some lizards is placed upon the top of the head, and has the appearance of a rudimentary eye, similar in structure to that of some of the Invertebrata.

In the Invertebrata there is an immense variety in the structure of the eye where such an organ is present. There are two main types, *simple* and *compound* eyes. In *simple* eyes (of which the human eye itself is the most highly organised form), every degree of complexity is present, from a mere pigmented spot, with or without a rudimentary lens, to an organ nearly as complicated as that of the Vertebrata (e.g. in some of the Cuttle-fishes), with a cornea, iris, lens, and retina all well developed. In these eyes, however, almost without exception, the nerve expands behind the retina, and the percipient elements are directed towards the light; while in the vertebrate eye the opposite arrangement obtains.

Some of these organs are so rudimentary that they can have no function beyond mere perception of light; but in cases where they are sufficiently developed to admit of the perception of objects, they see, roughly speaking, as our eyes do—that is to say, a more or less accurate picture of external objects is thrown on the expansion of nerve-endings corresponding to the retina, and its direction is reversed (see below).

In the *compound* eyes the whole principle of the structure and perception is different. They are best developed in Insects (q.v.), and in the higher Crustaceans; but occur in a rudimentary condition in some molluscs. The surface of such an eye is divided into a number of hexagonal facets, the cuticle of each generally forming a minute lens. Beneath each facet is a transparent rod, surrounded and separated from those adjacent to it by pigment, and leading inwards to the retinula, a group of cells in connection with the terminal fibrils of the optic nerve. In most familiar insects they form two hemispherical masses on the sides of the head. In some ants there are only fifty facets in each eye; in the house-fly about 4000; in some beetles as many as 25,000. It is probable that in these eyes only the rays of light which fall upon a particular facet exactly, or very nearly, in the direction of the transparent rod beneath it can reach the corresponding nerve-fibre, and that other rays are absorbed by the pigment around the rod. Each percipient element therefore receives light only from a very small portion of the field of vision, and the picture is a mosaic, each element of which is furnished by a different facet of the eye. The picture has obviously the same position as the objects it represents, instead of being inverted as in a simple eye. Most insects have simple as well as compound eyes; but the latter have by far the most perfect vision.

(3) We may now proceed to the consideration of the uses of the various parts of the eye. Assuming a general knowledge of the ordinary laws of geometrical optics (see OPTICS, LENS, &c.), we shall trace the course of the rays of light proceeding from any luminous body through the different media on which they impinge. If a luminous object, as, for example, a lighted candle, be placed in front of the eye, some of its rays fall upon the cornea, and are in part reflected, giving to the surface of the eye its beautiful glistening appearance; in part refracted or converged by it, to enter the aqueous humour, which exerts no perceptible effect on their direction. Those which fall on and pass through the outer or circumferential part of the cornea are stopped by the iris, and are either scattered or absorbed by it; while those which fall upon its more central part pass through the pupil, and are concerned in vision. In consequence of its refractive power, the rays passing through a somewhat larger surface of the cornea than the pupil are converged so as to pass through it and impinge upon the lens, which, as its refractive index is much greater than that of the aqueous and vitreous humours, by the convexity of both its surfaces very much increases the convergence of the rays passing through it. They then traverse the vitreous humour, whose principal use appears to be to afford support to the expanded retina, and are brought to a focus upon that tunic, forming there, if the eye be adjusted for the distance from which the rays proceed, an exact but inverted image of the object.

This inversion of the image may be easily exhibited in the eye of a white rabbit or other albino animal, after removing the muscles, &c. from the back part of the globe. The flame of a candle (A, B, C, fig. 10) held before the cornea may be seen inverted at the back of the eye (*a*, *b*, *c*), increasing in size as the candle is brought near, diminishing as it retires, and always moving in a direction opposite to that of the flame.

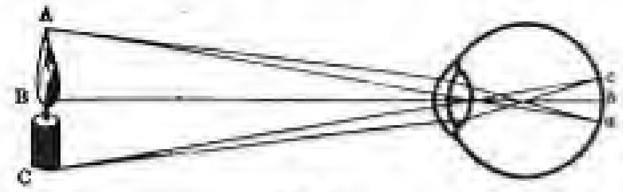


Fig. 10.

The adjustment of the eye for distinct vision at different distances, or *accommodation*, must next be considered. The normal eye in the position of rest is adjusted to see objects at a distance (practically all objects at 20 feet or more are seen with equal clearness): to see a near object (at 10 inches, say) a distinct effort is required, and when the effort ceases the object at once appears blurred. Careful observations and measurements by means of a suitable instrument (Ophthalmometer) of images reflected from the three principal refracting surfaces of the eye (cornea, anterior and posterior surfaces of crystalline lens) have shown that during

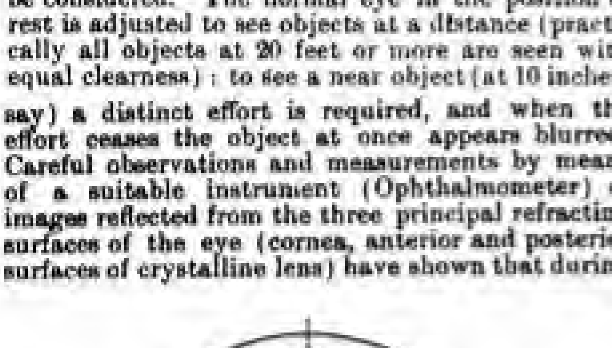


Fig. 11.—Action of Ciliary Muscle and Iris in accommodation:

A, (right or left) half; eye at rest, or focused for a distant object. B, (left or right) half; eye focused for a near object. *a*, cornea; *b*, sclerotic; *c*, anterior part of choroid; *d*, ciliary muscle; *e*, suspensory ligament of lens; *f*, anterior capsule of lens; *g*, iris.

accommodation for a near object (1) the position and curvature of the cornea remains unchanged; (2) the anterior surface of the crystalline lens approaches the cornea and becomes much more convex; (3) the posterior surface does not change its position, but becomes very slightly more concave. Accommodation, then, depends upon change of shape of the crystalline lens. The true explanation of the mechanism by which this is effected was first given by Helmholtz. The ciliary muscle, as already stated, has its fixed attachment all round within the sclerotic close to the margin of the cornea; and passes outwards and backwards to the anterior part of the choroid, close to the ciliary processes. When it contracts, therefore, it draws these structures inward; and with them the outer attachment of the suspensory ligament of the lens. The tension of this membrane is thus relaxed, and the elastic lens, whose form as well as position is controlled by it, is allowed to assume a more spherical shape. When the ciliary muscle ceases to contract, the converse takes place, and the lens is again flattened as the suspensory ligament and lens capsule become more tense. With the contraction of the ciliary muscle is always associated a contraction of the circular fibres of the iris, diminishing the size of the pupil; and when the ciliary muscle relaxes, the pupil enlarges again. This change, though of much less importance than the change in shape of the lens, is much more easy to observe.

Change of adjustment requires a short but measurable time; that from distant to near vision requires a little longer time than the converse; the former from a little over one to two seconds, the latter about one second.

As age advances, the power of accommodation steadily and quickly diminishes, not because the ciliary muscle gets weaker, but because the lens becomes less elastic. This change begins during youth, but is not commonly noticed before middle life. At ten years of age an object can be seen distinctly at less than 3 inches; at twenty, not nearer than 4 inches; at about forty-five, not nearer than 10 inches; at sixty, not nearer than 3 feet. After seventy-five, the lens is so unyielding that accommodation is altogether lost. When the shortest distance at which distinct vision is possible approaches that at which reading or work is usually attempted, the failure of accommodation begins to attract attention, and spectacles have to be resorted to to compensate for it. This condition has received the name of *presbyopia* or old sight, but must be clearly understood to be perfectly natural after the age of forty-five, and in no way to imply defect or weakness of the eyes.

The eye, regarded as an optical instrument, has numerous imperfections: the more important of these must be mentioned.

Spherical aberration (see LENS) is in part avoided by the iris, which, acting as a diaphragm, cuts off all but the central pencil of rays; in part by the forms of the refracting surfaces, which are not truly spherical, but ellipsoidal or hyperbolical—i.e. more curved at the centre than elsewhere; in part by the constitution of the lens (see above). What remains is, like *chromatic aberration*, for which no correction seems to exist, too slight to be perceptible.

Regular *Astigmatism* (q.v.) is present in almost all eyes, but is generally so small in amount as to be of no importance.

Imperfect Transparency of Media.—The stellate arrangement of the lamellæ of the lens is the cause of the rayed (or, as we say, star-shaped) appearance of a point of light. *Muscæ volitantes*, the clear threads or strings of beads often seen in looking at a bright surface flitting about when the eye is moved, are due to the shadows of the minute fibres and corpuscles naturally present in the vitreous humour.

(4) We must now consider how the image formed in the back of the eye by the dioptric media gives rise to vision. It is the retina, and only that part of it known as the layer of rods and cones (see fig. 5), which is directly affected by light.

Let two marks be made on a sheet of paper about 3 inches apart horizontally (a cross and a round mark to the right of it). Close the left eye, and holding the paper about a foot from the face, look steadily at the cross; the circle is also visible. Now bring the paper gradually nearer, keeping the right eye fixed upon the cross. The circle soon disappears; but becomes visible again when the paper is brought still nearer the eye. The *blind spot* in which the circle becomes invisible is the entrance of the optic nerve; hence we know that the nerve-fibres themselves are not sensitive to light. Further proof of this is given by *Purkinje's figure*, which is easily perceived as follows: Take a candle in a room otherwise dark, and holding it a short distance in front and to the outer side of one eye, move it from side to side, looking straight forward. A set of branching dark lines, the shadows of the retinal blood-vessels, will be seen (see fig. 4). These could not be perceived unless the sensitive portion of the retina lay behind the blood-vessels, which the nerve-fibre layer of the retina does not.

Stimulation of the retina, however it may be caused, gives rise to the sensation of light. Thus, slight pressure on one side of the eyeball causes an appearance of flashes of light towards the opposite side. A sudden blow on the eye, or the indirect shock to it of a fall on the head, makes one 'see stars.' Electric currents passed through the eye similarly cause a sensation of bright light. But true vision is only caused by rays of light falling upon the retina.

In what way light affects the layer of rods and cones we do not know. Probably it produces some chemical change, which leads to stimulation of the nervous elements. A substance called *visual purple* or *rhodopsin* has been found in the outer segments of the rods of some mammals, which is bleached on exposure to light, and restored in darkness. Photographic pictures of bright objects have even been obtained in eyes of rabbits, &c. by means of it. But as it is absent in the most sensitive portion of the human retina, it cannot be the chief factor in the production of vision.

The *fovea centralis* (see fig. 1) is the part of the retina where vision is most acute; as cones only are present here, it is clear that they are more delicately adjusted for their function than the rods, which greatly preponderate at other parts of the retina. When the eye looks straight at an object (or in technical language *fixes* it), its image falls upon this part of the retina. In *direct* vision, as this is called, two black marks on a white ground are distinguished as separate when the interval between them subtends an angle of about one minute at the eye. It is found by calculation that this angle, prolonged to the back of the eye, pretty nearly corresponds to the distance between two adjacent cones at the fovea centralis. The vision at other parts of the retina (*indirect* vision) is very much less acute, and less capable of accurate measurement. We have only to fix steadily one letter in a page of ordinary print to satisfy ourselves in how small an area we can see sufficiently distinctly to make out words without moving the eyes. The *field of vision*, or whole space within which objects are perceived by an eye while it is fixed upon one point, is very much wider, extending in each eye to more than 90 degrees from the fixation point or centre to the outer side, and rather less in other directions. Colour-vision is also most distinct at the centre of the field; and it is found that it diminishes more rapidly towards the outer portions than light-vision, so that near the limits of the field colours cannot be recognised.

There must be a certain amount of light for the purpose of vision. Every one knows that it is difficult and painful to discern objects in a very faint light; and, on the other hand, that on suddenly entering a brilliantly lighted room from the dark, everything appears confused for one or two seconds. There is, however, a gradual adaptation of the retina to different amounts of light. Persons long immured in dark dungeons acquire the power of distinctly seeing surrounding objects; while those who suddenly encounter a strong light are unable to see distinctly until the shock which the retina has experienced has subsided, and the iris has duly contracted. In protecting the retina from the sudden effects of too strong a light, the iris is assisted by the eyelids, the orbicular muscle, and to a certain extent by the eyebrows. Moreover, the dark pigment of the choroid coat acts as a permanent guard to the retina, and where it is deficient, as in albinos, an ordinary light becomes painful, and the protective appendages, especially the eyelids, are in constant use.

The persistence during a certain time of impressions made on the retina facilitates the exercise of sight. Such persistent impressions are called *after-images*. A momentary impression of moderate intensity continues for a fraction of a second; but if the impression be made for a considerable time, or be very intense, it endures for a longer period after the removal of the object. Thus, a burning stick, moved rapidly in a circle before the eyes, gives the appearance of a continuous ribbon of light, because the impression made by it at any one point of its course remains on the retina until it again reaches that point. It is owing to this property that the rapid and involuntary act of winking does not interfere with the continuous vision of surrounding objects; and, to give another illustration of its use, if we did not possess it, the act of reading would be a far more difficult performance than it now is, for we should require to keep the eye fixed on each word for a longer period, otherwise the mind would fail fully to perceive it. However great may be the velocity of a luminous body, it can always be seen; but if an opaque body move with such rapidity as to pass through a space equal to its own diameter in a less time than that of the duration of the retinal impression, it is altogether invisible; and hence it is, for example, that we cannot see bullets, &c. in the rapid part of their flight. In these cases the after-image is of similar brightness and colour to the original impression, and is known as a *positive* after-image. When the stimulation of the retina is very strong, or the retina itself in a very sensitive condition—e.g. in certain morbid states of the system and in twilight, a *negative* after-image appears, in which the bright parts of the original impression appear dark and *vice versâ*. An image of this kind may persist for some seconds or minutes or even longer. This physiological phenomenon has probably given origin to many stories of ghosts and visions. Thus, if a person has unconsciously fixed his eyes, especially in the dusk, on a dark post or stump of a tree, he may, on looking towards the gray sky, see projected there a gigantic white image of the object, which may readily be mistaken for a supernatural appearance. The phenomenon is easily seen on looking away from a bright window after directing the eyes to it for some time, when the bars appear as bright lines on a dark ground. Negative after-images are always of the complementary colour to that of the object. Thus, the image left by a red spot is green; by a violet spot, yellow; and by a blue spot, orange.

(5) Each eye can be moved from its ordinary position, looking straight forward, through an angle of nearly 60 degrees downwards, and of 35 to 45 degrees in other directions. But one eye never moves without the other. Two series of associated movements have to be distinguished: movements of both eyes in the same direction, and movements which *converge* the eyes, or bring the corneæ of both eyes towards each other. When a near object is looked at, the movement of accommodation is associated with a proportionate contraction of the internal recti of both eyes, so as to direct the visual axis, or in other words the fovea centralis, of each towards the object.

If we suppose the retinæ of the two eyes to be placed in contact, so that the foveæ centrales and the vertical meridians correspond, then all points which lie together in the two retinæ are called *corresponding points*, and have the property that simultaneous stimulation of both gives rise only to a single impression. An object whose image falls upon corresponding points thus appears single; otherwise it appears double. Hold up two fingers in line in front of the face. When the nearer one is looked at, it is seen single, but the farther appears double and somewhat out of focus; when the farther is looked at, it appears single, and the nearer is similarly doubled and blurred. Generally speaking, images of the great majority of the objects in the field of vision of both eyes must fall on non-corresponding points of the two retinæ; but as the attention is generally directed to the images of the object for which the eyes are accommodated, and as these, falling upon the foveæ centrales, are much the most distinct, the double vision of other objects is seldom noticed.

In the case of near objects, however, something more is needed to explain single vision. For example, take the case of a solid object. The two eyes, looking from different points of view, receive quite different images; the right eye sees more of the right side, the left eye more of the left. It is impossible that the images of each point of the object can fall upon accurately corresponding points of the two retinæ. Yet the appearance presented is that of a single object clearly defined. In this case then there must be in the brain-centres a power of combining in a single picture images which do not accurately correspond.

Various topics which the reader might perhaps have expected to find noticed, such, for instance, as 'the appreciation of solid forms by the sense of vision,' 'correct vision with an inverted image on the retina,' &c., which belong fully as much to metaphysics as to physiology, are discussed in the article on VISION. We may also refer those who desire information on these points to Professor Bain's treatise on *The Senses and the Intellect*.

For the anatomy of the eye, see Quain or other standard work. Lubbock in *The Senses of Animals* gives a concise account of the chief types of eyes in the Invertebrata. Helmholtz's *Physiological Optics* is the classical work on the optical aspects of the eye. The larger works on human physiology—e.g. Foster, Landois and Stirling—may also be consulted.

DISEASES AND INJURIES OF THE EYE, as might be expected from the delicate and complicated structure of the organ, are very numerous. But as the position of the eye and the transparency of its dioptric media give exceptional facilities for their detection and study, they are more thoroughly understood than those of any other organ. Only the most common and important can be referred to here.

Diseases of Conjunctiva are mainly different forms of inflammation, or *conjunctivitis*.

(*a*) *Simple* or *Catarrhal Conjunctivitis* may be acute or chronic. In the former case, it is commonly called 'cold in the eye.' The white of the eye is more or less reddened, and there is an increased discharge of gummy substance, causing the lids to cohere during sleep; a sensation is experienced as of sand or dust in the eyes, and there is a little increased sensitiveness to light. The acute form generally subsides in a few days without leaving any ill effects, unless improperly treated; the chronic form is often obstinate. The common popular treatment—viz. tying wet cloths or poultices over the eye, cannot be too strongly condemned; it may produce temporary relief of irritation, but aggravates the inflammation, and is very apt to lead to ulceration of the cornea. A mild astringent lotion should be used thrice or oftener in the day (cold tea; boracic acid 10 grains, alum 3 grains, to the ounce of water); and a little simple ointment or fresh butter applied to the lids at bedtime to prevent their becoming glued together. The chronic form often requires stronger remedies, but they should not be used except under medical advice.

(*b*) *Purulent Conjunctivitis* resembles the last, but is very much more severe, and highly dangerous. In its most characteristic forms it is known as *gonorrheal ophthalmia*, and *ophthalmia neonatorum* (eye inflammation of new-born children). To the latter variety about one-third of the blind persons in Europe owe their loss of sight. It is produced by inoculation of the eye with certain irritating discharges; and the discharge from an affected eye will infect any other eye with which it comes in contact. The conjunctiva becomes intensely red and swollen, and the lids partake in the swelling so that they cannot be opened; there is severe burning pain, and after two days or more a profuse discharge of matter. The danger to sight is due to the fact that the cornea is extremely apt to be destroyed, wholly or in part, before the inflammation subsides. In infants the disease usually begins on the third day after birth, and is, as a rule, less severe than in the adult, but unfortunately is often overlooked, or regarded as of no importance till irreparable mischief has been done. Scrupulous cleansing of the eyes immediately after birth, preferably with corrosive sublimate lotion (1 grain to 8 ounces) is the best preventive. When the disease has commenced, very frequent removal of discharge and hourly washing with boracic or corrosive sublimate lotion should be resorted to. But all such cases should at once be put under the charge of a medical man.

(*c*) *Pustular* or *Phlyctenular Conjunctivitis* is a form of inflammation very frequent in children, much less so in adults. It is an indication of a lowered state of the general health, and its treatment must include fresh air and light, good food, and cod-liver oil or some other strengthening medicine. The inflammation does not extend all over the white of the eye, but is localised in one or more sections of it, and is most intense near the margin of the cornea, where one or more small rounded blebs or pimples may be seen. It is often accompanied in children by extreme tenderness to light; but the tendency to this is aggravated by a bandage or darkness. The local treatment should be bathing with boracic acid or some other mild astringent lotion; but, unless the case be very mild, a medical man should be consulted.

(*d*) *Granular Conjunctivitis*, or *trachoma*, is an exceedingly chronic and intractable disease. It is sometimes called Egyptian ophthalmia, having been extremely prevalent in the French army in Egypt in 1798. In Europe it is most common among the Jews and the Irish, but is often troublesome in industrial schools and similar institutions. It is encouraged by overcrowding, bad ventilation, and other unfavourable hygienic conditions, and is undoubtedly somewhat contagious. It is characterised by numerous distinct semi-transparent elevations on the conjunctiva of the lids, chiefly the upper. It often lasts for months or years, and is chiefly dangerous on account of the shrinking of the conjunctiva produced by it, which leads to trichiasis, Ectropion (q.v.), and opacity of the cornea. It should always be treated by a skilled medical man.

(*e*) In *Diphtheritic Conjunctivitis* there is a 'false membrane' formed on the conjunctiva, as in Diphtheria (q.v.) in other situations. It is happily rare in Britain.

Diseases of the Cornea.—The most common and important are inflammations associated with ulceration—i.e. destruction of some of the corneal substance. This is replaced when healing takes place by imperfectly transparent tissue, and results very frequently in great impairment of vision (irregular Astigmatism, q.v.), even where no obvious mark remains. The appearances, symptoms, and appropriate treatment of different forms and stages of corneal ulceration are extremely various, and cannot profitably be discussed here. Skilled medical advice should always be obtained. It must suffice to say that the eyes should be rested, shaded from light, and bathed, generally with boracic or corrosive sublimate lotion. Poulticing or tying up the eyes should never be resorted to unless under a doctor's orders, as it is usually still more mischievous than in conjunctivitis.

In one form of inflammation of the cornea, called *interstitial*, there is an appearance all over it of great haziness or even complete opacity, but without breach of surface. It occurs usually in boyhood or girlhood, and though alarming in appearance and tedious, generally results in complete recovery. Mr Jonathan Hutchison first pointed out that it is usually a manifestation of congenital syphilis.

The *sclerotic* is comparatively seldom affected by disease, probably on account of its slight vascularity and comparatively low vitality.

The *iris* is liable to inflammation (*iritis*), characterised by severe deep-seated pain, redness of the white of the eye, contracted pupil, and much dimness of sight. The inflammation, if unchecked, produces adhesion between the posterior surface of the iris and the anterior capsule of the lens, which may permanently interfere with vision, or even lead ultimately to complete loss of sight. Local treatment at the early stage by Atropia (q.v.) dilates the pupil and prevents the formation of adhesions. Unless the result of injury, iritis usually depends on constitutional causes, especially syphilis and rheumatism, and treatment of these is of prime importance for its cure. Medical aid should be sought at once; for atropia, which is most beneficial in iritis, is disastrous in glaucoma, a disease which sometimes resembles it in many of its symptoms.

The chief disease of the *lens* is opacity, or Cataract (q.v.); it may also be displaced or dislocated, either from an anomaly in its development, or as the result of injury.

Diseases of the deeper structures of the eye (choroid, vitreous humour, retina and optic nerve) usually require for their recognition the use of the Ophthalmoscope (q.v.). Generally speaking, they are associated with little or no pain, and attract the patient's attention in consequence of the dimness of vision they produce. They are much less amenable to treatment in most cases than affections of the more superficial parts.

Inflammation and atrophy of the *choroid* occur in several forms; the most distinct are those occurring in syphilis, in old age, and in connection with high degrees of short-sightedness (progressive myopia, see below).

The *vitreous humour* rarely if ever becomes diseased, except in consequence of changes in the ciliary body or choroid. The abnormal condition generally manifests itself in more or less opaque threads or films, which move with the movements of the eye, and appear to the patient as clouds or dark lines interfering with vision, much more large and distinct than the 'muscæ volitantes' present in the normal eye.

The *retina* may be the seat of hemorrhage or of inflammation in many forms of disease. The most common and characteristic retinitis is that associated with Bright's disease (q.v.), which is almost always of very serious import. Its main artery may become blocked by a plug carried into it from the heart or elsewhere (*Embolism*; see ARTERIES, DISEASES OF), an accident which causes sudden and usually almost complete loss of sight. Not unfrequently, too, the retina becomes detached from the choroid, either as the result of disease or injury, and floats in the vitreous chamber in front of its normal position, a condition greatly interfering with sight, and most difficult to improve.

The *optic nerve* may become inflamed (*optic neuritis*), most commonly in consequence of an inflammation or tumour of the brain or its membranes. It may degenerate (*optic atrophy*) either after inflammation or independently of it. In the latter case, however, as well as the former, there is in the great majority of instances some disease of other parts of the nervous system (brain or spinal cord).

There are two diseases chiefly affecting the deeper parts of the eye which it is desirable to describe at some length, as their course is often insidious, and their results when not recognised early, most disastrous, while timely interference is often signally successful in preserving the sight. These are *glaucoma* and *sympathetic ophthalmia*.

Glaucoma occurs most commonly during or after middle life, frequently in persons whose eyes are hypermetropic (see below). It may come on with such suddenness and intensity that vision is lost in a few hours, or its course may extend over years. Always, however, if unchecked, it tends to progress till sight is destroyed. Both eyes are usually affected, but often one long before the other. In many cases there are *premonitory* symptoms, consisting in temporary attacks of cloudiness of vision, during which the patient, when looking at a light (e.g. a gas or candle flame), sees it surrounded by coloured rings or halos. During this 'premonitory stage,' the vision is perfectly normal between the attacks; but they become more frequent and prolonged, till it is permanently impaired. Variability of the symptoms is usually a characteristic feature in all stages of the disease. Often in the later phases, and always in acute and severe cases, much pain is experienced in and around the eye affected. The pupil is large and immobile; the iris and lens farther forward than normal; the cornea more or less hazy; and some of the blood-vessels of the white of the eye larger and more visible than they should be. The most important sign of the disease, and the feature on which many of its characteristics depend, is increased hardness of the eyeball, owing to increase of its contents. The exact cause of this increased hardness is not fully understood, nor the way in which some of the symptoms observed depend upon it; but it varies with the symptoms, being always more marked when the pain and dimness are at their worst. Chronic insidious cases are often mistaken for cataract, though the use of the ophthalmoscope readily distinguishes between the two conditions; in the most acute cases, the headache, sickness, and general disturbance of the system is sometimes so severe that the condition of the eyes is overlooked, and the disease is looked upon as a 'bilious attack' till the vision is hopelessly destroyed.

The disease was regarded as absolutely hopeless till Von Graefe, in 1857, proved that the removal by operation of a portion of the iris of a glaucomatous eye might arrest the process. This proceeding (*iridectomy*), though by no means uniformly successful, does good in the majority of cases, and has been of enormous benefit. But if too long delayed, it is of no avail for the restoration of vision.

It is of great importance that atropin or belladonna should not be applied to an eye with any tendency to glaucoma, as they aggravate the disease, and sometimes even produce it. Eserin, the active principle of the Calabar bean, has an action on the eye antagonistic to atropin, and can often keep glaucoma in check, though it rarely cures it. Pilocarpin, the active principle of Jaborandi, has a similar action.

Sympathetic ophthalmia is the name given to a form of inflammation, chiefly of the iris and ciliary body, occurring in an eye previously healthy in consequence of disease or injury of the other. Almost, if not quite, invariably the eye first affected has had its coats (cornea or sclerotic) perforated; and the process in the second eye may begin at any time, from a fortnight to many years after this occurrence. It is an extremely insidious disease, sometimes quite painless; but also extremely dangerous, for it often leads to total loss of sight. The early symptoms are watering, tenderness to light, and dimness of sight, especially of near objects. When it begins, there is almost invariably irritability and tenderness to touch in the eye which is the origin of the disease. It can be absolutely prevented by early removal of the eye first affected; but if this be delayed till the inflammation has begun in the second eye, it may be useless. An eye which has received a perforating wound, particularly in the 'ciliary region'—i.e. just outside the cornea—may therefore at any subsequent period become a source of danger to the other eye; and if its vision is destroyed there can be no doubt that it should be removed. Even if some useful sight is retained, this may sometimes be desirable; but at all events, every one who has suffered from such an injury to one eye should know that the slightest symptoms of irritation or failure of sight in the other should at once lead him to seek skilled advice. Recent researches have rendered it probable that this form of inflammation is caused by micro-organisms, though this is not quite definitely established.

Errors of refraction are those defects in the dioptric media of the eye which, without diminishing their transparency, interfere with the formation of a retinal image in the normal way. Astigmatism (q.v.) has already been noticed; presbyopia is the failure of accommodation natural to age (see above). It remains to describe *myopia*, or short-sightedness, and *hypermetropia*, or long-sightedness. In most cases the condition of both eyes is alike, or nearly so; but exceptionally there is a considerable difference between them (*anisometropia*).

The knowledge of this branch of the subject was first systematised and placed on a satisfactory basis by Donders (1818-89), a distinguished Dutch physician and physiologist, professor of Physiology at Utrecht, in his work on *Anomalies of Accommodation and Refraction of the Eye* (Eng. trans. pub. by Sydenham Society, 1866).

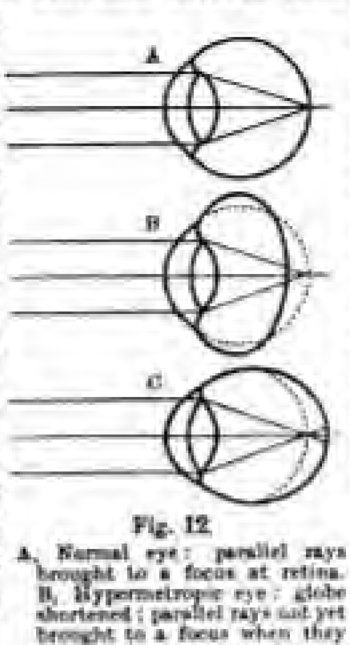


Fig. 12

A, Normal eye: parallel rays brought to a focus at retina. B, Hypermetropic eye: globe shortened; parallel rays not yet brought to a focus when they reach retina. C, Myopic eye: globe lengthened; parallel rays brought to a focus in front of retina.

The normal eye in the position of rest is adjusted for parallel rays—i.e. for a distant object, and by means of the accommodation can be focused for a near object. The short-sighted eye at rest is adjusted for divergent rays—i.e. for a near object; accommodation enables it to focus for a still nearer object, but it can make no change enabling it to see clearly beyond its 'far point'—i.e. that for which it is adjusted at rest. The long-sighted eye at rest is adjusted for convergent rays, which do not occur in nature; accommodation enables it to focus parallel rays (from distant objects), or divergent rays (from near objects), but not to see so near as a normal eye of the same age.

These defects generally depend on an abnormality in the length of the antero-posterior diameter of the eyeball; in short-sighted eyes it is greater, in long-sighted less than the normal (see fig. 12). They can be corrected by the use of suitable glasses; in short-sighted eyes concave lenses are used, which render the rays of light falling upon them more divergent; in long-sighted eyes convex lenses, which render the rays less divergent or convergent.

Loss of accommodation occurs with the progress of years in such eyes, just as in normal ones, though the effects are somewhat different. The short-sighted eye continues to be able to see near at hand without spectacles; but, contrary to the popular belief, has no other advantage over the normal eye as age advances, for vision of distant objects does not improve. The long-sighted eye in time loses the power of seeing even distant objects without spectacles; and the higher the degree of long-sightedness the earlier the age at which this occurs.

An abnormal shape of the eye, on which these 'errors of refraction' usually depend, is frequently hereditary, and is incurable; it usually remains stationary after early adult life, but in some cases of myopia, where it is associated with disease of the choroid, tends to become worse (*progressive* or *malignant* myopia). The object of treatment must be to counteract, so far as possible, the inconvenience resulting; and this can generally be done by the use of spectacles or eyeglasses. No general rules can be laid down as to their use, as much depends not only on the degree of the abnormality, but on the age and occupation of the individual. If glasses conduce to comfort and to the preservation of the sight, no mere regard for appearance should prevent their being worn.

Diseases of the Eyelids.—A *stye* is practically a minute Boil (q.v.) formed in the eyelid, and discharging at its margin. It should be fomented frequently with hot water till it bursts. Constitutional treatment is often desirable, as styes often occur, like boils, in groups or series.

Small rounded swellings (*tarsal cysts*) often form under the skin of the lids, owing to obstruction of the duct of a Meibomian gland. They are usually painless, but require for their cure the evacuation of their contents through a puncture on the inner surface of the lid.

A form of Eczema (q.v.) often occurs at the margin of the lids, called *blepharitis*, most commonly in delicate children. It can usually be readily cured if attended to in time; but if neglected, as it too often is, leads to destruction (blear eyes) or misdirection (trichiasis) of the eyelashes, and much subsequent trouble. It is characterised by redness and ulceration of the edges of the lids, usually masked by crusts adhering to the lashes. Frequent removal of these, with the daily application of a stimulant ointment (e.g. yellow oxide of mercury, 8 grains to the ounce of simple ointment), and the use of tonics generally effect a cure. Inversion (Entropion, q.v.) and eversion (Ectropion, q.v.) of the margins of the lids, and misdirection of the eyelashes (trichiasis), so that they rub against and irritate the cornea, are troublesome affections, usually requiring operation for their removal.

Diseases of the Lachrymal Apparatus.—A 'watery eye' (*epiphora*), when no irritating affection of the eye itself is present, usually proceeds from stricture of the nasal duct, or some other cause, which prevents the tears from discharging by their natural channel into the nose. The condition can be remedied in most cases by slitting up the canaliculus (see fig. 7), and passing graduated probes through the duct to restore its patency. If unattended to, it generally leads sooner or later to abscess of the lachrymal sac, with much swelling and pain.

Injuries.—In no part of the body is there so often great disproportion between the severity of an injury and the amount of pain and irritation it occasions. A penetrating wound sometimes causes less discomfort than a mere particle of sand beneath the eyelid. Any wound or blow affecting the eye, therefore, particularly if it interfere at all with the sight, should be seen by a doctor as speedily as possible. Substances thrown against the eye may injure it. Quicklime is rapidly destructive to the eye, slaked lime and mortar less so. When one of these, or any other alkaline caustic, has got into the eye, diluted vinegar should at once be used to neutralise it. If it is oil of vitriol (sulphuric acid) or another acid that has been the cause of the injury, a weak solution of soda may be used in the first place to neutralise the acid. After this, sweet oil is the best thing to introduce, until the surgeon arrives. In gunpowder explosions near the eye, besides the burn, the particles are driven into the surface of it, and will cause permanent bluish stains over the white of the eye, unless they are carefully removed at the time. When chips of glass, stone, &c. are driven into the interior of the eye, there is little hope of its being saved from destructive inflammation, though fragments of iron and steel are sometimes removed by means of a strong electro-magnet, with a successful result. In these and all other *penetrating* wounds—i.e. those where the cornea or sclerotic is broken through, the possibility of subsequent sympathetic ophthalmia in the other eye must be borne in mind. When only partially sunk into the cornea, as is often the case with sparks of cinder or iron, &c., or 'fires,' as they are called, the rubbing of the projecting part on the eyelid causes great pain, and the surgeon has not much difficulty in removing them. Most commonly these, or other 'foreign bodies,' as particles of dust, sand, seeds, flies, &c., when not speedily washed away by the tears, merely get into the space between the eyeball and the lids, almost always concealed under the upper, as it is the larger, and sweeps the eye. They cause great pain, from the sensitiveness of the papillary surface of the lid, and of the cornea over which they are rubbed by its movements, soon excite inflammation, and their presence, as the cause, is apt to be overlooked. The lid must be turned round to find them. To do this, pull the front or edge of the lid forward by the eyelashes, held with the finger and thumb, and at the same time press down the back part of the lid with a small pencil or key, directing the patient to look downwards. The lid will readily turn round, when the body may be seen about its middle, and may be removed with the corner of a handkerchief. Another plan, which the person himself may try, is to pull forward the upper lid by the eyelashes, and push the lashes of the lower lid up behind it, when the foreign body may be brushed out. After the bodies are removed, a feeling as if they were still there may remain for some time. See BLIND, COLOUR-BLINDNESS.

ARTIFICIAL EYES are worn for the sake of appearance in cases where, as the result of disease or injury, an eye has either been totally lost, or rendered unsightly. They are, moreover, distinctly advantageous in cases where a gaping socket is liable to irritation by dust, cold winds, &c. They cannot be used unless the size and prominence of the eyeball is at least somewhat diminished. Few surgeons in Britain recommend them to be worn unless the eyeball is either entirely removed (enucleation), or has the front part removed (abscission), or all the contents extracted (evisceration); for the artificial eye is apt to cause irritation of the sensitive anterior portion of the globe, and may lead to the development of sympathetic ophthalmia (see p. 515). Enucleation is the most certain means of preventing this; but the other operations named above allow of better movement, and give a more natural appearance to the eye.

An artificial eye consists of a thin shell, usually of enamelled glass, coloured to present as nearly as possible the same appearance as the visible part of the normal eye. Quite recently Celluloid (q.v.) has been used instead of glass, and is said to last better, as its surface is not affected by the secretions; while it has the advantages that it is not brittle, and can easily be pared to fit the socket accurately. To obtain a satisfactory result, it is necessary either to have the eye specially made, or to be able to select from a very large stock; as colour of iris, size of pupil, tinge of sclerotic, as well as curvature of surface and form of margin, must be adapted to the particular case. They are therefore to be got to most advantage in large cities, such as London or Paris.

The eye must not be worn continuously, but removed each night and replaced in the morning. It is slipped in under the lids, which hold it in position. Even when the globe has been entirely removed, the muscles, by their attachment to the tissues remaining in the orbit, usually effect movements in the same direction, though not of the same extent, as those of the normal eye; and it is often difficult for any but a practised observer to detect to what the difference between the two is due. A single glass eye can rarely be worn more than a year without being polished, for the surface becomes roughened by the action of the tears, &c., and irritates the lids as they rub over it. The wearing of a glass eye therefore means an expenditure of at least one or two pounds a year, and is thus out of the power of many poor people to whom it would otherwise be an advantage.

Fats are natural oils, solid at the ordinary temperature, which occur in plants and animals. They are all compounds of glycerin with various fatty acids. The animal fats are to be regarded as ethers formed by replacing the removal atoms of hydrogen in the triatomic alcohol glycerin, $\left.\begin{matrix}C_3H_5\\H_3\end{matrix}\right\}O_3$, by the acid radicles of the acetic and oleic series. The most important of these fats are Palmitin, Stearin, and Olein.

$$\text{Palmitin}\ \left.\begin{matrix}C_3H_5\\(C_{16}H_{31}O)_3\end{matrix}\right\}O_3$$

$$\text{Stearin}\ \left.\begin{matrix}C_3H_5\\(C_{18}H_{35}O)_3\end{matrix}\right\}O_3$$

$$\text{Olein}\ \left.\begin{matrix}C_3H_5\\(C_{18}H_{33}O)_3\end{matrix}\right\}O_3$$

In addition to these we have in milk, butter, &c. small quantities of the neutral fats of Butyric, Caproic, Caprylic, Capric, and Myristic acids. They are oily bodies; some solid, others fluid, at the ordinary temperature. They are insoluble in water and in cold alcohol, soluble in hot alcohol, in ether, chloroform, &c. Under the action of caustic alkalies or superheated steam they are decomposed into their fatty acid and glycerin. The fat of different animals differs in its characters according to the relative proportion of these various fats which it contains. Thus, the fat of the dog, which contains a large proportion of olein, melts at a comparatively low temperature, while the fat of the sheep, on the other hand, which is particularly rich in stearin, has a much higher melting point.

Whatever be the nature of the fat, it occurs in the animal body inside the living units or cells in the form of small globules. Fats appear to be an almost invariable constituent of all living protoplasm; but in certain tissues they accumulate in very large amounts. This is especially the case in the cells of loose fibrous tissue, where the deposition of fat is frequently so great as to form regular masses or lobules. Under the skin, in the abdomen, in the orbits, round the heart, and in various other places these masses are well marked.

The quantity of fat in the human body varies considerably at different periods of life. In the earlier stages of fœtal existence we find scarcely any fat; in new-born children there is usually a considerable quantity of this substance deposited under the skin, and the organism continues rich in fat till the age of puberty, when a marked diminution of the substance occurs. It again increases about middle life, and then occasionally occurs in great excess; for example, three or four inches of fat are not unfrequently found under the skin of the abdomen in corpulent persons.

The fats of the body are derived not only from the fats of the food, but also from both carbohydrates and proteids. It has now been clearly shown that an animal takes up and stores in its body any fat which may be administered in the food, and that it may thus for the time being have the chemical nature of its fat entirely altered. After a time, however, the living protoplasm of the body seems to be able to convert the foreign fat so stored into the proper fat of the animal.

By feeding dogs on a flesh diet, and carefully analysing the excreta, Pettenkofer and Voit have shown that the flesh of the food is a source of fat in the body. That carbohydrates such as sugar and starch are also sources of fat is a matter of popular belief. Various researches have clearly demonstrated that this belief is correct. By feeding young growing pigs on a diet of known composition, and afterwards killing them and analysing their bodies, it was shown that the fat found was in such amounts that it could have been derived only from the carbohydrates of the food.

The physiological value of the fats is due partly to their physical and partly to their chemical characters. The uses of the fat deposited beneath the skin are, first, to protect the body from external shocks by a uniform diffusion of pressure through the whole adipose tissue; and, secondly, to keep up the heat of the body, by materially checking, through its very slight conducting power, the loss of free heat by radiation. This use of the fat is most clearly seen in some of the lower animals (the seal, whale, &c.), which are exposed to very low temperatures. Another physical use of fat is to promote the mobility of various organs. Hence, in cases of extreme emaciation, it always remains in the parts where motion is most essential, as the heart and the orbit of the eye.

The chief chemical use of fat is as a store of potential energy for the body. On account of the large amount of carbon and the small amount of oxygen contained in the molecule, it is peculiarly valuable in this respect. Measuring the potential energy in gramme degrees, we find that 1 gramme of fat yields 9069 gramme degrees of heat; 1 gramme of proteids yields 4368; 1 gramme of carbohydrates yields 3912. Unfortunately the process of digestion and assimilation of fat is difficult, and for this reason, as well as on account of its relatively high price, only a moderate amount can be daily consumed.

Fatty Acids. See OILS.

Fencing may be generally described as the scientific handling of a sword or bayonet in attack or defence, though the term is usually limited to the use of the rapier. It is taught in every gymnasium, and in the British army every officer on joining is put through a course of gymnastics of which it forms a part. Non-commissioned officers are taught at the Aldershot Gymnasium, and then appointed instructors in the various garrisons where gymnasiums exist, and to all cavalry regiments, the troopers of which are also trained by them.

FENCING WITH THE RAPIER OR FOIL is admitted to be the best exercise that can be taken. Every muscle of the body is brought into play by it, and hand and eye are trained to act in unison. No description can pretend to teach it. Even an instructor who is not thoroughly capable does more harm than good in attempting to teach fencing, as bad habits are acquired which it is most difficult to unlearn; and, unless every movement is accurately and properly made, there is no science and very little interest in its practice.

The foil in practice used as a substitute for the rapier should have a tapering blade about 32 inches long, and square in section, with a gutta-percha button on the point, and a weighted pommel to the hilt, so as to balance it properly. Masks of wire netting are absolutely essential to protect the face, and leather gloves, jackets, and aprons should also be worn.

Except in Spain, where one straight cut at the head is allowed, the only attack with the rapier or foil is by *thrust* and *lunge* (or *longe*)—i.e. straightening the elbow so as to bring the sword and arm into line, and then striding forward about 18 inches with the right foot. The defence is by slight movements of the sword hand, which cause the *foible* (upper half) of the assailant's blade to glide along the *forte* (lower half) of the defender's foil, and outside it, so as to pass clear of his body, while his point is always kept towards the front, ready to *ripost* (longe after parrying) without an instant's delay. The proper positions and movements when *on guard*, *engaged*, *longeing*, *parrying*, *advancing*, and *retreating* must be most carefully learned from an instructor, and assiduously practised, as well as the various *attacks*. A reproduction (fig. 1) of the diagram given by Captain Chapman in his excellent little book, *Foil Practice*, shows the four lines of attack and the nine parries usually taught. It will be sufficient to mention that a *counter parry* describes a circle

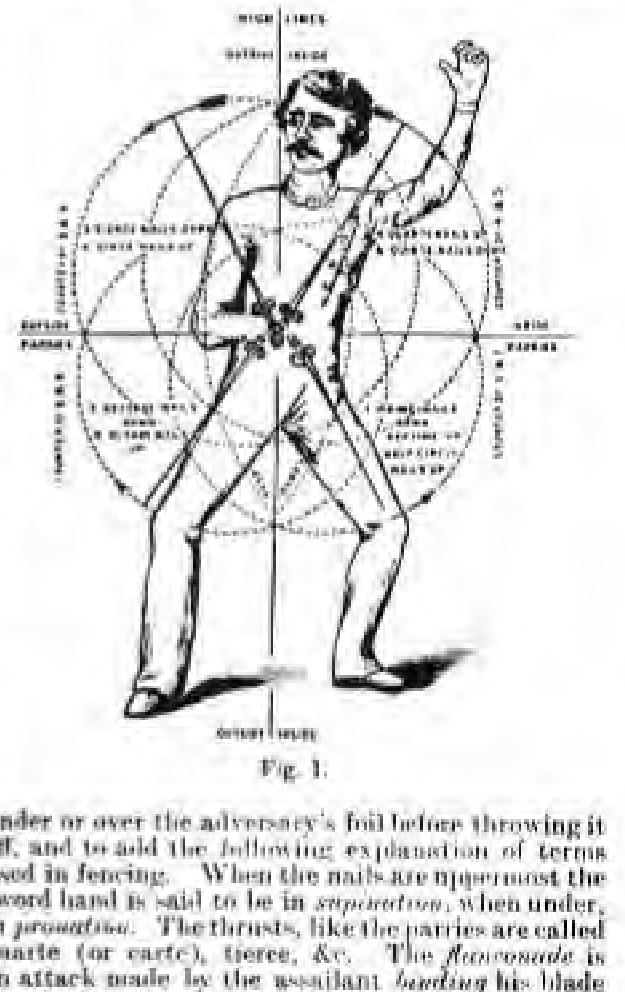


Fig. 1.

under or over the adversary's foil before throwing it off, and to add the following explanation of terms used in fencing. When the nails are uppermost the sword hand is said to be in *supination*, when under, in *pronation*. The thrusts, like the parries are called quarte (or carte), tierce, &c. The *flanconade* is an attack made by the assailant *binding* his blade round the adversary's and longeing at his body under his arm. An attack may be a combination of any of the following movements preceding a longe: *disengage*, when swords are crossed, changing from one line of attack to another by passing under the adversary's sword; *cut over*, the same change by whipping over his sword; *one, two*, a double disengagement; *double*, both blades horizontal, and circling round parallel to one another; and *beat*, a side-blow of one blade on the other. If a second thrust is made after longeing, and without springing up to guard again, it is called a *reprise*; and, if made to take advantage of a wide parry not followed by a ripost, a *remise*. *Time thrusts*, like cross-counters in boxing, parry a thrust by a thrust.

The system of fencing compiled by Mr Archibald Maclaren, of the Oxford Gymnasium, is that used in the British army, and differs from others in teaching only four parries—viz. quarte, tierce, seconde, and semicircle. All are formed in the usual manner, except the last, which, by raising the hand slightly and elevating the blade as high as the face, guards both the upper and lower openings on the inner or left side, carrying the adversary's blade over the right shoulder, and leaving him completely exposed to the return thrust. In Spain and Italy the left hand is used as an auxiliary in parrying, and in Italy is aided by a dagger, or a cloak.

THE BROAD-SWORD EXERCISE differs from fencing with the foil, in that the weapon employed is intended to cut as well as thrust. For practice a stout, straight stick is used, called a 'single-stick,' having a buffalo-hide or basket handle to protect the knuckles.

The position and movements of the combatant are very similar to those for fencing with the foil. There are seven cuts, with seven corresponding guards, and three thrusts, as shown on the accompanying diagram, which represents a target placed opposite a pupil, with its centre in a line with the centre of his breast.

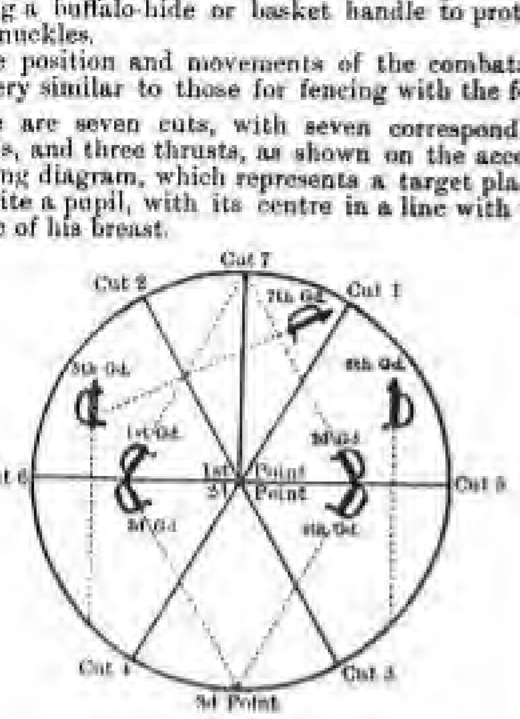


Fig. 2.

The cuts cross the whole circle through the centre along the *thick* lines. Nos. 1, 3, and 5 are inside cuts, and may be directed against any part of the left side, and inside of the right leg; 2, 4, and 6 are outside cuts, attacking the right side, and right leg on the outside. No. 7 is a vertical cut, aimed at the head. The dotted lines show the several guards. The points or thrusts are shown by the black dots. The 'parry' consists in bringing the wrist nearly to the right shoulder; whence, as centre, a circular sweep of the sword is made from left to right.

CAVALRY SWORD EXERCISE differs from the foregoing, which is not suitable for horsemen. It has four cuts on each side, two at a mounted, and two at a dismounted adversary. Each cut has a corresponding point and guard.

THE BAYONET EXERCISE taught in the British army has been assimilated to Maclaren's system of fencing. The guards are formed in as nearly as possible the same manner, except that, of course, the rifle is held in both hands, one at the grip, and one in front of the back-sight. The latter remains almost stationary, while the movements of the other form the parries. A new and most effective thrust, called the *throw*, has been introduced. When making it, the forward hand quits the rifle, which is thrown forward to the full extent of the other arm.

As to the relative values of the sword, rapier, and bayonet, the first, requiring for each cut two motions, one up and the other down, cannot but be much slower in its action than either of the other two; while the last, from its weight, is exhausting and clumsy. The second, on the other hand, has none of these objections, and in skilled hands is by far the most deadly weapon.

Fermentation (Lat. *fervēre*, 'to boil'), a change brought about in organic liquids by the agency of a ferment. Ferments are of two classes, *soluble* and *organised*. (1) *Soluble ferments, or zymoses.*—This class is of less importance than the other. When isolated, the ferments are white, amorphous substances, freely soluble in water and in glycerine, and usually insoluble in alcohol. They are found in grain which has germinated (malt), in saliva, gastric juices, &c., and also usually occur along with organised ferments like yeast. The commonest soluble ferment is Diastase (q.v.), occurring in malt. Others of considerable importance are ptyalin, found in saliva; pepsin, in gastric juice; synaptase, in bitter almonds; myrosin, in mustard, &c. These all resemble one another very closely in properties, and all have the power to cause substances like starch and cane-sugar to combine with water, forming glucose and analogous uncrystallisable sugars, thus:

$$\underset{\text{Cane-sugar.}}{C_{12}H_{22}O_{11}} + \underset{\text{Water.}}{H_2O} = \underset{\text{Dextrose.}}{C_6H_{12}O_6} + \underset{\text{Levulose.}}{C_6H_{12}O_6}.$$

Diastase converts the starch contained in barley first into dextrine, then into glucose or grape-sugar, thus:

$$\underset{\text{Starch.}}{C_6H_{10}O_5} + \underset{\text{Water.}}{H_2O} = \underset{\text{Glucose.}}{C_6H_{12}O_6}.$$

The same effects can be produced by boiling these bodies with dilute acids. Soluble ferments act most rapidly at a temperature of 75° C. (167° F.), and are destroyed by boiling. Their action is impeded or entirely stopped by many substances such as borax, citric and tartaric acids, and some antiseptics; on the other hand, prussic acid, mercurial salts, alcohol, chloroform, ether, and essential oils have little effect on soluble ferments.

(2) *Organised Ferments.*—The chemical changes induced by these always depend on the life-process of minute organisms (see GERM THEORY) which feed upon sugar or other substances in solution, and excrete the product of the fermentation. Fermentation nearly always consists of a process of breaking down of complicated organic substances like sugar into simpler ones like alcohol and carbonic acid. Economically, alcoholic fermentation is of far greater importance than any other. It is caused by the so-called yeast-plant (*Saccharomyces cerevisiae*) in solutions containing uncrystallisable sugar (glucose). The sugar may be originally in various forms. In malt extract for beer it exists as glucose or dextrine; in grape-juice for wine manufacture, chiefly as glucose; in potatoes for making potato-spirit or 'marc,' as starch; or, finally, as cane-sugar itself. The latter two, when fermented, are first converted by the soluble ferment which accompanies yeast into glucose, and that is then transformed by the yeast itself into alcohol, carbonic acid gas, and small quantities of glycerine, succinic acid, and other substances.

Brewers' yeast contains an enormous number of one-celled organisms (*Saccharomyces cerevisiae*), on which its activity entirely depends. Under the microscope these are seen to be colourless, nearly transparent, roughly spherical bodies of a diameter of about 0·00035 inch. When the conditions are favourable—i.e. nourishment plentiful, and temperature about 80° F., the yeast-cells multiply very rapidly by budding. When food is deficient they may multiply by the formation of spores. Fermentation of grape-juice to form wine depends on organisms of the genus Saccharomyces, of which there are many species not yet very sharply defined. The various species are found in different kinds of wine must, or even in different positions in the same fermenting-vat.

Putrefaction and rotting are very much akin to fermentation, and all depend on the presence and growth of minute organisms.

The following are some of the varieties of fermentation which possess considerable importance or interest:

Acetous Fermentation.—It has long been known that wine under certain circumstances absorbed oxygen from the air and turned into vinegar. This is now known to be due to the conversion of the alcohol into acetic acid by an organism, the *Mycoderma aceti*. The wine is allowed to trickle slowly through barrels filled with beech-shavings, through which fresh vinegar has previously been poured in order to impregnate the shavings with the 'mother of vinegar,' which contains the Mycoderma. Under the microscope the *M. aceti* appears as very minute elongated rods (diameter about 0·00008 inch) united into chains.

Lactic fermentation is the cause of the souring of milk. It is caused by a definite rod-like organism or bacillus, which reaches the milk from the air. The life-conditions of this ferment are almost the same as those of the yeast ferment, but there are certain substances attacked by the one and not by the other, and *vice versâ*. During lactic fermentation the sugar of milk is converted into lactic acid, which ultimately causes the curdling of the milk.

Butyric Fermentation.—This is one of a large number of processes of fermentation usually roughly classed as putrefaction, on account of the foul smell produced during the action. It is caused by an organism (*Fermentum butyricum*) which has the power of breaking down such substances as sugars, starches, tartaric and citric acids, and albumenoid substances, producing butyric acid and carbonic acid.

Ammoniacal Fermentation is also one of the processes which form part of putrefaction. Most organic substances containing nitrogen yield ammonia as one of the products of putrefaction. This process is of great importance in nature, as by it nitrogenous animal matter, contained in manure, is converted into salts of ammonia, which can be absorbed by earth. They are then acted on by the nitrifying organism which is found in all fertile soils, and by it slowly oxidised into nitrates, which can then be absorbed by the roots of plants.

Conditions of Fermentation.—As all fermentation, except that produced by soluble ferments, is caused by living organisms, the *optimum* conditions of fermentation are (1) sufficiency of nourishment and moisture; (2) temperature about blood-heat (98° F.); (3) absence of poisonous substances. Deficiency of nourishment or water may kill a ferment, or may cause it to form spores, which then resist drying, and may even exhibit vitality after boiling, which is instantly fatal to all active ferments. A low temperature renders ferments inactive, a temperature much above 100° F. is fatal to their life. All antiseptic or disinfectant substances (see ANTISEPTICS), such as corrosive sublimate, chlorine, fumes of burning sulphur, eucalyptus-oil, act by impeding or destroying the life of the ferments. Many of the products of fermentation are themselves antiseptics, as in the case of alcohol, so that alcoholic fermentation always arrests itself when the spirit has reached a certain strength. Some ferments cannot live in presence of air, others require it; while others again are indifferent to it. For further information, see *Fermentation*, by Schützenberger (Inter. Sc. Series), and the article 'Fermentation' in Thorpe's *Dictionary of Applied Chemistry*.

FERMENTED LIQUORS are alcoholic beverages made by fermentation of saccharine fluids and juices; the principal being the different kinds of *ale* or *beer*, made by fermentation of an infusion of malt—chiefly of barley, but also sometimes of other kinds of grain—and *wine*, made by fermentation of grape-juice. *Cider* is made by fermentation of the juice of apples; *perry*, of that of pears; *palm-wine*, by fermentation of the sap of different kinds of palm. Fermented liquors, commonly called wines, are also made from the juice of various kinds of fruit, as currant-wine from that of the red currant; and from the juice of some roots, as parsnip-wine from that of the parsnip, &c. The sap of the American Aloe, or *Agave* (q.v.), yields the fermented liquor called *Pulque*, much used in Mexico. A wine is made from the sap of the birch, and that of some other trees is used for a similar purpose. *Mead* is a fermented liquor made from honey. From every fermented liquor a kind of *spirit* may be obtained by distillation.

Ferrates are combinations of ferric acid, $HFeO_2$, a weak unstable compound of iron and oxygen, with bases. See IRON.

Ferridcyanogen, or FERRICYANOGEN, a compound radical supposed by chemists to exist in ferricyanic acid and the ferricyanides. It cannot exist in the free state. The most important of the ferricyanides is that of potassium, also called red prussiate of potash. It is prepared by passing a stream of chlorine gas into a solution of potassium ferrocyanide till the liquid turns dark red; on evaporation the salt is obtained in crystals. The reaction is as follows:

$$\underset{\substack{\text{Potassium}\\\text{Ferrocyanide.}}}{2Fe(CN)_6K_4} + \underset{\text{Chlorine.}}{Cl_2} = \underset{\substack{\text{Potassium}\\\text{Chloride.}}}{2KCl} + \underset{\substack{\text{Potassium}\\\text{Ferricyanide.}}}{Fe_2(CN)_{12}K_6}.$$

The chief use of potassium ferricyanide is for the manufacture of Turnbull's blue, an important dye. This substance is formed when a solution of a ferricyanide is mixed with that of a ferrous salt (green vitriol, for instance); it consists of ferrous ferricyanide, $Fe_5K_2(CN)_{12}$. Ferric salts yield no precipitate with ferricyanides. Strong acids separate ferricyanic acid, $H_6Fe_2(CN)_{12}$.

Ferrocyanogen, a compound radical supposed by chemists to exist in ferrocyanic acid and the ferrocyanides. It cannot exist in the free state. The most important of the ferrocyanides is the potassium salt; it is prepared in the following manner. A mixture of potassium carbonate, iron filings, and animal matter, such as dried blood, horn clippings, &c., is heated to redness in iron pots. Potassium cyanide is thus formed. The mass is extracted with water, the cyanide combines with iron, forming ferrocyanide, which dissolves, and may be purified by recrystallisation. The chief use of potassium ferrocyanide is for the preparation of Prussian blue—ferric ferrocyanide (see DYEING and CALICO-PRINTING)—which is formed on the addition of a ferric salt to solution of the ferrocyanide. A ferrous salt produces a white or light-blue precipitate of ferrous ferrocyanide. By the action of dilute sulphuric acid on potassium ferrocyanide, prussic acid is produced; if strong sulphuric acid be used, the ferrocyanide is completely decomposed, yielding carbonic oxide gas, and sulphates of iron, potassium, and ammonium. Hydrochloric acid causes the separation of ferrocyanic acid, $H_4Fe(CN)_6$, in small white crystals insoluble in hydrochloric acid. Most of the metallic ferrocyanides are insoluble, and many have characteristic colours. Iron cannot be detected in either ferro- or ferricyanides by any of the common reactions. Potassium ferrocyanide is not poisonous. The chemistry of these compounds is not yet thoroughly understood.

Ferrotype, or ENERGIATYPE, a photographic process, first made public by Robert Hunt in 1844, in which the negative was developed by a saturated solution of protosulphate of iron, with mucilage of gum-arabic, and fixed by soaking in water to which a small quantity of ammonia or hyposulphite of soda had been added.

Fibrin is a proteid substance which appears in the blood after it is shed, and by its appearance gives rise to the process of coagulation or clotting. Freshly prepared fibrin is a stringy, elastic, white substance. Its elementary composition is carbon, 52·6; hydrogen, 7·0; nitrogen, 17·4; sulphur, 1·2; oxygen, 21·8 = 100·0. It gives the various reactions of the proteid substances (see PROTEIDS). It is insoluble in water, and only slowly soluble in solutions of the neutral salts. It is precipitated by a saturated solution of sulphate of magnesium. It must therefore be considered as nearly allied to the globulin group of proteids.

Fibrin may best be obtained by whipping blood as it is shed with a bundle of twigs, which after a time become surrounded by masses of the fibrous elastic threads of fibrin. These may then be washed to free them from the various constituents of the blood. The mode of appearance may be well studied by allowing a layer of blood to coagulate on a microscopic slide under a cover glass, and then gently washing the cover glass to which the clot adheres with a stream of water. It will be seen to consist of a delicate reticulum of fibrils with granular-looking masses at many of the nodal points. The fibrils appear to have shot out from these granular masses.

The source of fibrin is a matter upon which our knowledge is at present imperfect. The most recent investigations tend to show that a substance belonging to the globulin group of proteids, and known as fibrinogen, which occurs in the blood-plasma before coagulation, becomes precipitated as fibrin when the blood is shed. What is the cause of this precipitation we do not know. Formerly it was supposed that the white corpuscles broke down and set free a ferment which set up the change. More recently the possible connection of the third element of the blood—the blood platelets—with the process has been suggested by various pathological investigations. Apparently the granular nodal masses already described are composed of these platelets. Although the wet fibrin derived from blood appears somewhat bulky, when dried and weighed its amount is found to be very small—on an average only 0·2 per cent.

Fibrous Substances. Such of these as are used in the arts are either of animal or vegetable origin, with the exception of Asbestos (q.v.), which is mineral. Fibres which can be spun and woven, or made into cloth or paper by a felting process, have some peculiarity of structure which fits them for such purposes. Human hair or horse-hair is not suitable for ordinary textile fabrics, because either resembles a very thin flexible rod with smooth sides, so that when an attempt is made to twist a number of them into a yarn, or form them into a felted substance, they will not hold together. Horse-hair used singly is made into cloth because it is exceptionally strong. But nearly all fibres suitable for woven or felted fabrics, such as wool, silk, cotton, or flax, have on their surface serrations or projections of some kind, or they have a proneness to twist and curl, either of which characters causes them to interlock, so that when they are spun into yarn they do not untwist again. These little prominences or projections are only seen when the fibre is highly magnified.

In addition to suitable structure, the value of a fibre for industrial purposes depends upon its strength and elasticity, and upon its capability of being bleached and dyed. Length and fineness are also considered, as well as abundance of supply.

The wool of the sheep and the shawl goat is described under WOOL and CASHMERE GOAT. See their respective heads for alpaca, mohair, fur, and silk. There are a few other animal fibres of some interest or importance, such as camel's hair, from which an excellent cloth is made, and cow-hair, which is used in considerable quantity for inferior kinds of woollen goods. A fibre of a silky nature is obtained from the byssus of a large Mediterranean bivalve shell-fish (*Pinna nobilis*), which is made into shawls and gloves.

Different parts of plants yield fibres. Only dicotyledonous plants have a true bark, and from these come the most important textile fibres of vegetable origin. These generally consist of strong, fine, flexible bast fibres from the bark sheath, of which flax, hemp, rhea, and jute are examples (see BAST). The most valuable of all, however—viz. cotton, consists of hairs which surround the seeds of the plant. In monocotyledonous plants, which also yield many serviceable fibres, these are commonly obtained from the fibrous portions of leaves and of leaf-stalks. More rarely they occur as hair-like fibres which form appendages to leaves or surround their base. Coir fibre is from the husk of the nut of the cocoa-nut palm.

Vegetable fibres consist essentially of Cellulose (q.v.), a substance which is not easily acted upon by chemical reagents such as affect allied bodies found in plants. This is an important property in connection with some of the manufacturing processes through which they require to pass.

Cotton, flax, hemp, jute, and coir are described under their respective heads; rhea or China-grass under BŒHMERIA; and New Zealand flax (*Phormium tenax*) under FLAX. The vegetable fibres noticed in what follows, though less known than those used in our principal textile industries, are nearly all of some importance commercially. Besides these there are quite a number of plants yielding fibres known to have valuable properties which have not, except in the countries in which they grow, received any industrial application.

FIBRES FROM EXOGENOUS PLANTS.—*Asclepias syriaca* (Silk Weed).—The seeds of this plant are covered with a silky down which is used for a variety of purposes, such as the stuffing of beds and for mixing with wool for certain kinds of cloth and felt. The species is a native of Syria, but is also found in North and South America, and is cultivated in some parts of Europe.

Beaumontia grandiflora is another plant yielding a hairy or silky fibre from the seeds. This is considered to be one of the best and strongest of the seed-hairs called 'vegetable silk.'

Broussonetia papyrifera (Paper Mulberry).—A fine white cloth called tapa is made in a number of the Pacific Islands by beating the bark of this tree. The bark of this and another species of Broussonetia is much used for making paper in Japan. Quite recently the fibrous portion of the bark of the young shoots of white mulberry (*Morus alba*) has been used as a textile material in Italy (see MULBERRY).

Crotalaria juncea (Sunn Hemp).—Indigenous to Southern Asia and the tropical portion of Australasia; cultivated all over India. The fibre is very suitable for cordage, considerable quantities being exported from India for this manufacture.

Daphne longifolia, *D. papyracea*, *D. Wallichi*.—The fibre of the bark of each of these Indian plants is used in the manufacture of paper and ropes.

Eriophorum comosum (*Pollinia eriopoda*) (Babar-grass, Cotton-grass).—This plant is very common in many parts of India. The down at the base of the seeds is largely used in India for making paper, ropes, and cordage.

Hibiscus cannabinus (Hemp-leaved hibiscus, Deccan hemp).—In the North-west Provinces, as well as in other parts of India, this small herbaceous shrub is largely cultivated for its fibre, which is sometimes used to adulterate jute. It is inferior to the latter in quality, being rather coarse and harsh, though strong. In India it is made into ropes and nets and largely into paper.

Humulus lupulus (Hop).—From the hop vine a useful fibre is obtained, which is turned to account for making cloth in Sweden. In England it has been made into millboard.

Pinus sylvestris (Pine-wool).—In recent years fibre obtained from the leaf-needles of the Scotch fir has, on the continent of Europe, been made into a blanket stuff for hospitals, flannels, and hosiery. It is usually mixed with cotton or wool. The material is believed to have medicinal properties.

Tilia europæa (Common Lime-tree).—The bast fibres of this tree are extensively used in Russia for mats, ropes, and other purposes.

FIBRES FROM ENDOGENOUS PLANTS.—*Agave americana* (Spanish aloe).—An excellent fibre is obtained from this plant, which grows in great abundance in all parts of tropical America. It has also been successfully introduced into some countries of the Old World. The fibre is made into ropes, twine, and netting, as well as into matting and imitation haircloth.

Agave mexicana.—A plant distinct from the last, though often confounded with it. The fibres of both are used for the same purpose. Paper was made by the ancient Mexicans from *A. mexicana* in the same way as the Egyptians made it from the papyrus.

Agave sisalana (Sisal hemp).—The fibre of this species, which grows in Yucatan, Mexico, and Central America, is especially valuable for ship cables, as it has been found to resist the action of sea-water better than most other materials used for their manufacture. Sisal hemp is sent in considerable quantities to the United States, but some of it is also sent to Europe.

Attalea funifera (Piassava).—From this palm much of the cordage used on the Amazon River is made. The strong fibres used surround the young leaves. These are known in commerce as piassava fibre, or at least one kind of it, which is used in Europe chiefly for brushmaking. Another kind of piassava is got from *Leopoldinia piassaba*, also a Brazilian palm.

Bromelia ananas (*Ananassa sativa*) (Pine-apple).—In some places, such as the Bahamas and India, this plant is cultivated for its fruit, but in Malacca, Java, China, and some other eastern places chiefly for its fibre. Several species of bromelia yield useful fibres. The *B. pigna* of the Philippines yields the fine thread from which the costly pina cloth or pina muslin is made. *B. sylvestris*, called in Central America the *pita*, and in Mexico the *istle*, also produces an excellent fibre.

Carludovica palmata (Panama screw-pine).—The unexpanded leaves yield the straw of which Panama hats, so much valued for their durability, are made.

Caryota urens (Kittool).—From the leaves of this Indian palm the kittool fibre, now largely used to mix with bristles in brushmaking, is obtained. Strong ropes are made of it in India.

Copernicia cerifera (Carnauba or Carnahuba—q.v.—palm).—A Brazilian palm remarkable for the number of useful products obtained from it. In that country the fibres of its leaves are used for ropes, mats, brooms, &c.

Corypha australis (Australian cabbage-palm).—The fibre obtained by splitting the leaves is made into clothing, netting, and hats.

Macrochloa tenacissima (Esparto-grass).—Esparto fibre is now manufactured into Paper (q.v.) on a great scale. For this purpose it is extremely well suited, being fine and strong, with a tendency to curl. Until comparatively recently much of the esparto-grass of commerce was supposed to be the *Lygeum spartum*, an allied plant.

Musa textilis (Manilla hemp).—The chief use of this fibre is in ropemaking, but matting is also made from it on a considerable scale in Dundee. It is prepared from the leaf-stalks of a wild plantain growing in the Philippine Islands.

FIBRE FROM AN ACROGENOUS PLANT, *Cibotium barometz* (Pulu fibre).—The fibre so called surrounds the stalks of the fronds (leaves) of the plant, which is a fern growing in the Sandwich Islands. This fibre, like some of those occurring as hairs on seeds, is called 'vegetable silk.' It is used in the United States and Australia for stuffing in upholstery work.

Fighting-fish (*Betta pugnax*), a small fresh-water fish, especially at home in Siam, where it is reared on account of its curious pugnacity. It belongs to the family Labyrinthici, which includes other interesting fishes, such as the Climbing Perch (Anabas), the beautiful Paradise-fish, the well-flavoured Gourami. When two fighting-fish are brought together they often rush immediately to combat; or it is even enough to introduce a looking-glass into the water, when the fish hastens to attack its own image. Fish-fights are a favourite amusement of the Siamese; the license to exhibit them yields a considerable annual revenue; and an extraordinary amount of gambling takes place in connection with them—not merely money and property, but children and liberty being sometimes staked. When the fish is quiet its colours are dull; but when it is excited they glow with metallic splendour, and 'the projected gill-membrane, waving like a black frill around the throat, adds something of grotesqueness to the general appearance.'

Filter. When solid matter is suspended in a liquid in which it is insoluble, it may be separated by various means (see CLARIFICATION), one of which is filtration. The process of filtration consists in passing the liquid through some porous substance, the interstices of which are too small to admit of the passage of the solid particles, the principle of the action being the same as that of a sieve. One of the simplest forms of filter is that commonly used in chemical laboratories for separating precipitates, &c. A square or circular piece of blotting-paper is folded in four, the corner where the four folds meet is placed downwards in a funnel, and one side is partly opened, so that the paper forms a lining to the funnel. The liquid passes through the pores of the paper, and the solid matter rests upon it. The chief advantages of this filter are its simplicity and the ease with which the solid matter may be removed and examined.

A simple water-filter for domestic purposes is sometimes made by stuffing a piece of sponge in the bottom of a funnel or the hole of a flower-pot, and then placing above this a layer of pebbles, then a layer of coarse sand, and above this a layer of pounded charcoal three or four inches in depth. Another layer of pebbles should be placed above the charcoal, to prevent it from being stirred up when the water is poured in. It is obvious that such a filter will require occasional cleaning, and renewal of the charcoal. By a small addition to this a cottage-filter may be made which, for practical use, is quite equal to the most expensive filters of corresponding size. It consists of two flower-pots, one above the other; the lower one is fitted with the sponge and filtering layers above described, and the upper one with a sponge only. The upper pot should be the larger, and, if the lower one is strong, the upper one may stand in it. The two pots thus arranged are placed upon a three-legged stool with a hole in it, through which the projecting part of the lower sponge passes, and the water drops into a jug placed below. The upper pot serves as a reservoir, its sponge stops the coarser impurities, and thus the filtering layers of the lower one may be used for a long period without being renewed, if the upper sponge be occasionally cleaned. Care must be taken to wedge the upper sponge tightly enough, to prevent the water passing from the upper pot more rapidly than it can filter through the lower one.

A great variety of filters are made on a similar principle to the above, but constructed of ornamental earthenware or porcelain vessels of suitable shape. In purchasing a filter, the buyer must not be satisfied with merely seeing that the water which has passed through it is rendered perfectly transparent—this is so easily done by a new and clean filter—but he should see that the filter is so constructed as to admit of being readily cleansed, for the residual matter must lodge somewhere, and must be somehow removed. When large quantities of water have to be filtered this becomes a serious difficulty, and many ingenious modes of overcoming it have been devised. In most of these water is made to *ascend* through the filtering medium, in order that the impurities collected on it may fall back into the impure water. Leloge's ascending filter consists of four compartments, one above the other; the upper part, containing the impure water, is equal in capacity to the other three. This communicates by a tube with the lowest one, which is of small height. The top of this is formed by a piece of porous filtering-stone, through which alone the water can pass into the third compartment, which is filled with charcoal, and covered with another plate of porous stone. The fourth compartment, immediately above the third, receives the filtered water, which has been forced through the lower stone, the charcoal, and the upper stone. A tap is affixed to this, to draw off the filtered water, and a plug to the second or lowest compartment, to remove the sediment.

Leloge's Filter:
1, 2, 3, 4, the four compartments; *ab*, the first porous stone of third or filtering compartment; *cd*, the east filtering stone of *d*; *e*, the plug to remove for cleaning out second compartment; *f*, a loose sponge at entrance of communicating tube.

A large number of other ascending filters have been patented. Siphon filters are cylindrical pewter vessels, containing the filtering media, to which is attached a long coil of flexible pipe. When used, the cylinder is immersed in the water-butt or cistern, the pipe uncoiled, bent over the edge of the cistern, and brought down considerably below the level of the water. It is then started by applying the mouth to the lower end, and sucking it till the water begins to flow, after which it continues to do so, and keeps up a large supply of clear water. This, of course, is an ascending filter, and the upward pressure is proportionate to the difference between the height of the water in the cistern and that of the lower end of the exit tube (see SIPHON). Filtering on a large scale is effected by using several tanks or reservoirs, in the first of which is coarse material such as gravel, the water passing from this to a second, and from there through a finer filter to the main receptacle, where the filtered water is stored and drawn off for use.

A common water-butt or cistern may be made to filter the water it receives by the following means: Divide the cistern or butt into two compartments, an upper and a lower, by means of a watertight partition or false bottom; then take a wooden box or small barrel, and perforate it closely with holes; fit a tube into it, reaching to about the middle of the inside, and projecting outside a little distance; fill the box or barrel with powdered charcoal, tightly rammed, and cover it with a bag of felt; then fit the projecting part of the tube into the middle of the false bottom.

Various means of compressing carbon into solid porous masses have been patented, and filters are made in which the water passes through blocks of this compressed carbon. Most of these are well adapted for the purpose, but their asserted superiority over filters composed of layers of sand and charcoal is doubtful. A very elegant and convenient portable filter for soldiers, travellers, and others who may require to drink from turbid ponds and rivers is constructed of Ransome's filtering-stone, and is also made of the compressed carbon. A small cylinder of the stone or carbon is connected with a flexible india-rubber tube in such a manner that the cylinder may be immersed in a river, the mouth applied to a mouthpiece at the other end of the tube, and the water drawn through the filtering-cylinder.

It has been questioned whether soluble matter, such as common salt, is in any degree removed from water by filtration. Theoretically it was assumed that this is impossible, since the filter only acts mechanically in stopping suspended particles; but the results of experiments show that from 5 to 15 per cent. of the soluble salts were separated by sand-filters such as above described. Another most important matter is to ascertain to what extent soluble organic matter may be decomposed by filtration, especially by charcoal filters, and to ascertain how long charcoal and other porous matter retains its property of acting on organic matter in watery solution (see CHARCOAL). This is of the highest importance, as it sometimes happens that water of brilliant transparency, and most pleasant to drink, on account of the carbonic acid it contains, is charged with such an amount of poisonous organic matter as to render its use as a daily beverage very dangerous. A filter of animal charcoal will render London porter colourless. Loam and clay have similar properties. The separation from drinking-water of pathogenic microbes (microscopic sources of pestilence) and their germs is very difficult, on account of their extreme smallness; but it has been effected by using porous unglazed earthenware as the filtering medium. It is, however, rather troublesome in practice, as pressure is demanded, and the very fine pores are soon clogged. They may be cleansed by raising the filter material to a red heat. A duplicate is therefore required.

When a liquid contains mucilaginous or other matter having viscous properties, there is considerable difficulty in filtering it, as the pores of the medium become filled up and made watertight. Special filters are therefore required for syrups, oils, &c. Such liquids as ale, beer, &c. would be exceedingly difficult to filter, and therefore they are clarified by the admixture of albumen, gelatin, or some substance with clarifying properties. Oil is usually passed through bags made of horse-hair or twilled cotton cloth (Canton flannel). Syrups are filtered on a small scale by confectioners, &c. by passing them through conical flannel bags, and on a large scale in *crowed bag-filters*, made by enclosing a large bag within a smaller one. Thick syrups have to be diluted or clarified with white of egg, to collect the sediment into masses, and then they may be filtered through a coarse cloth strainer. Vegetable juices generally require to be treated in this manner. See BEER, WINE, SUGAR, &c.; and for filtering on the large scale, see WATER-SUPPLY.

The simple laboratory filter has to be modified when strong acid or alkaline solutions, or substances which are decomposed by organic matter, require filtration. Pure siliceous sand, a plug of asbestos, pounded glass, or clean charcoal are used for this purpose. Some recommend gun-cotton as a filter for such purposes.

Air Filters.—The extraordinary powers of charcoal in disinfecting the gaseous products evolved from decomposing animal and vegetable matter have been made available in constructing an apparatus for purifying air that is made to pass through it. A suitable cage, containing charcoal in small fragments, is fitted to the opening from which the deleterious gases issue, and is found to render them perfectly inodorous, and probably innocuous. Mechanical impurities suspended in air may be filtered out by forcing the air through a plug of cotton-wool, as in firemen's respirators.

Firearms. The generic term 'firearm' includes Cannon, Rifles, Guns, Revolvers (q.v.), and other weapons in which an explosive is used as an agent for the propulsion of projectiles. The history of the invention of Gunpowder (q.v.) is an appropriate prelude to that of firearms, the existence of the latter being wholly dependent upon the discovery of a certain recondite quality in the former.

Inflammable material has been employed in warfare from remotest antiquity; sulphur and resinous gums were the ingredients of some, and naphtha and bituminous substances with nitre of other, of the mixtures known to the ancients as 'Greek fire,' 'wild-fire,' or 'Medea's oil;' but the vessels in which these inflammable compounds were deflagrated cannot properly be termed firearms.

A weapon of the pyrotechnical species was developed by some of the eastern nations, and is said to have been used extensively until the 15th century for the frightening of horses and cattle on pillaging expeditions and in warfare. The weapon was in construction similar to a 'Roman candle' of the pyrotechnists, the inflammable filling of Grecian wax and metal filings being alternated with layers of gunpowder and balls of tow mixed with sulphur; the weapon was lighted at the muzzle, and as the 'filling' burned down, the balls were shot out by the gunpowder immediately beneath them.

The knowledge of gunpowder and firearms may be presumed to have extended in a westerly direction through the Arabs, who used them in the 8th century under the name of 'manjaniks,' and introduced them into Spain in the 13th century. Seville was defended in 1247 by cannon throwing stones; Niebla in 1259; and in 1273 Abu Yusuf employed cannon firing stone balls at the siege of

Sidi-Moussa, near Algiers. Ghent possessed a small cannon in 1313, and Florence ordered cannon and *iron* balls about 1325. In Germany, Amberg possessed a cannon in 1301, and in 1327 the English employed some Hainaulters, who used cannon for King Edward III. against the Scotch. Cannon were used in 1339 at Cambrai, in 1340 at Mirepoix, in 1345 at Monségur, in 1346 at Crécy. In 1350 some North German knights armed themselves with *iron* guns, and in 1365 Einbeck was very effectually defended with the aid of firearms.

Different countries had different names for these early firearms—in Italy 'bombardo,' in France 'quenon,' in Germany 'buchsen,' in the Netherlands 'vogheleer,' in England 'crackeys' or 'engynnes' of war; but it was not until the 15th century that firearms were classified and named accordingly. *Bombards* were short, capacious vessels, from which stone balls were shot with small charges to a short distance and at considerable elevation; they were essentially the parents of the present bombs or mortars. The *cannon* (*canna*, 'a reed'), on the other hand, were, for some time at least, of extremely small bore, scarcely larger than muskets of the 18th century; they discharged leaden bullets, and would have probably been used as hand-weapons but for their cumbrous and heavy workmanship, which necessitated small carriages. Arms of this description are doubtless those referred to as having been brought by Richard II. to the siege of St Malo, to the number of 400 pieces, where they are said to have kept up an incessant fire day and night on the town *without* success.

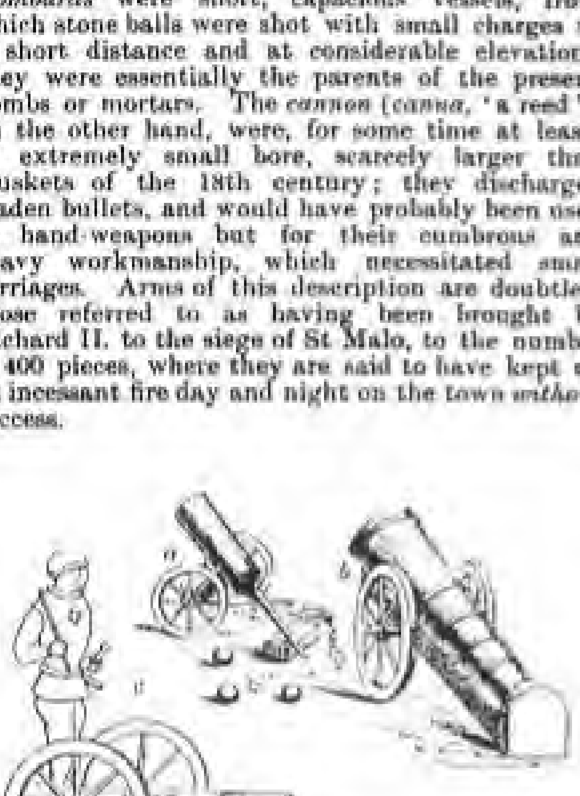


Fig. 1.
a (from the *Chroniques de St. Denis*), 14th century; *b*, bombard of the 15th century (from Froissart); *c*, cannon of the 15th century (from *Les Vigiles de Charles VII.*).

All these early firearms were usually loaded to the muzzle, and fired at an extreme angle. Charles V. classed mortars separately, mounted cannon upon carriages, added trunnions, and effected other improvements in his artillery, which consisted of cannon; great, bastard, and small culverins; falcons and falconets. The classification of firearms led to the development of various types to be used for specific purposes, and an invention which effected a great improvement to one type was useless or inapplicable to another. Cannon of 120 tons and pocket-pistols of 4 ounces, although they have a common origin, have not a common history. Cannon were of wrought iron, built up by the handicraft of the smith, of rods and rings, and were used as they left his forge. Cannon of a copper and tin alloy were cast at Augsburg in 1378; they have since been made of hollowed blocks of stone; or cylindrical holes, bored in the solid cliffs, have been used to fire projectiles, as at Alexandria, Constantinople, and Gibraltar; they have been made of wood, of rope, of leather, and of papier-maché, as well as of almost every pure and alloyed metal it is possible to cast or forge. The early cannon were chiefly used at sieges, as their weight and the badness of the roads, added to the inefficiency of the weapons themselves, precluded their advantageous use as field-pieces, and if utilised in a pitched battle they were fired but once. But on the one hand the development of cannon into small portable weapons produced hand firearms, and on the other the increase of size and weight led to the large weapons so important for the defence of fortifications. Of this type the 'Mons Meg' of Edinburgh Castle is an early specimen; it weighs nearly 4 tons, and fired a stone shot of over 300 lb. The powder-chamber is of a less diameter than the bore of the cannon, in this particular resembling the mortar, and exhibiting the reverse of the principle of enlarged powder-chamber now employed. Such cannon were made at Ghent in the 15th century.

The culverin, a useful size of cannon, was employed generally in England until after the Commonwealth. Culverins fired stone shot, iron balls, leaden bullets, and composite projectiles—a leaden jacketing being cast round uneven stones to make them heavier, and the better to fit the interior of the cannon. Such culverins and projectiles were made by the blacksmiths of Deritend, Birmingham, in the 17th century, and were used at the battle of Worcester.

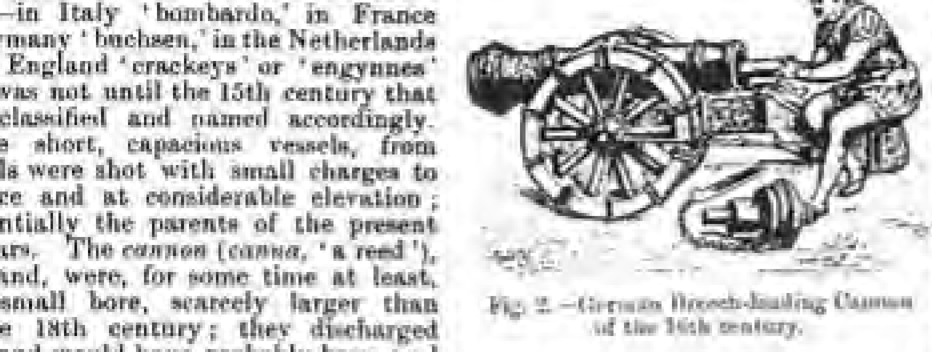


Fig. 2.—German Breech-loading Cannon of the 16th century.

Field-pieces were not greatly developed until the 18th century, when the improved finish of the interior allowed of long and uniform ranges, and a certain definite accuracy being obtained. The breech-loading field artillery are now of a high degree of excellence; but whether firing shot or shell the limit of power will be found in recoil, as is the limit of accuracy in the correctness of the aim.

For defensive purposes, as well as for certain offensive operations, special arms were required and constructed; of these the long-barrelled wall-pieces for defence; the 'petard,' and *mortars* firing bars, oblong and square bullets, for making a breach; explosive shells and grenades for clearing a trench; grape and chain shot for mowing down compact squares of infantry or destroying the rigging of battle-ships, are the best known. From the 'orgue de bombardes,' another type of early firearm, the quick-firing, many-barrelled machine guns have been developed. The earliest form of this weapon is the 'ribaudequin,' of Italian origin, which consisted of a number of small cannon and pikes arranged upon a portable carriage; it was fired but once during an engagement, and was primarily intended as a defence against a cavalry charge. The 'orgue de bombardes' (fig. 3), with more cannon (fired simultaneously) and fewer pikes, succeeded the ribaudequin.

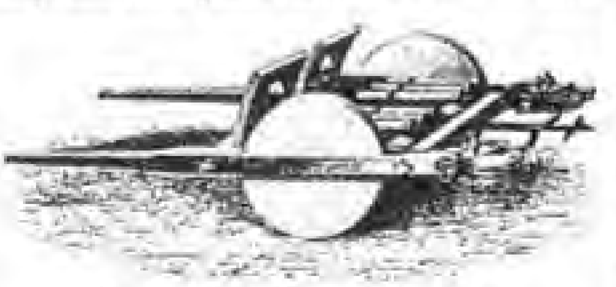


Fig. 3.—French Orgue des Bombardes.

Further developments survived into the era of percussion firearms.

With the cannon and quick-firing machine guns, the improvements have depended less upon the ingenuity of inventors than on the achievements of mechanical science to accomplish accurate workmanship, and work great masses of material as skilled workmen can handle smaller pieces. The improvements in explosives, in the quality of the metal, and in the machinery available, have rendered possible the production of such immense weapons, that the limit of size would appear to be rather in the cost of manufacture and the enormous expenditure risked upon the aim, than in the inability of modern mechanicians to produce still larger and more powerful weapons.

The development of the hand firearm, on the contrary, called for the ingenuity of the handicraftsman, and at first this ingenuity was exercised in the combination of a firearm concealed with some other weapon, so that its firing unexpectedly

Fig. 4.—Pistol Battle-axe.

should produce a consternation; and for the same reason repeating and double-barrelled weapons were produced. Firearms were incorporated with daggers, swords, pikes, clubs, maces, axes, and shields; and it was the use of these devices by cunning warriors that disgusted the knights and led to their loss of prestige, and hastened the decay of feudalism. The hand firearms owed their success quite as much to the consternation caused by their unexpected discharge as to the execution done by their projectiles: hence Montaigne wrote in 1585, when the muskets in use were much superior to the earlier culverins, that their effect, apart from the shock caused by the report, was so insignificant that he hoped the use of them would be discontinued. It was as a surprise weapon that Neapolitan brigands and French postillions were armed with whips, the handles of which were cunningly devised and well-hidden pistols.

The culverin or hand cannon was a small tube of ½ or ¾ inch internal diameter, fixed to a straight piece of wood or welded to an iron handle. At the close of the 15th century they were extensively used. In 1471 culveriners were in the army of Edward IV. after his landing at Ravenspur, Yorkshire; and hand firearms were used at the siege of Berwick in 1521. The smallest hand culverins—about 4 feet in length and weighing 15 lb.—were used on horseback; heavier weapons up to 60 lb. weight were used by the foot-soldiers. The culveriner was attended by a 'varlet' to aid in firing the piece, which was always supported upon a forked rest. The arquebus

Fig. 5.—Early Hand-culverin.

was a smaller and improved culverin, requiring but one man. Grose writes of the equipment of the culveriner: 'He had, in addition to the unwieldy weapon itself, his coarse powder, for loading, in a flask; his fine powder, for priming, in a touch-box; his bullets in a leathern bag, with strings to draw to get at them; whilst in his hand were his musket-rest and his burning match.'

The touch-hole of the culverin was in late patterns placed in the side, instead of on the top as with cannon, a flash-pan was added, and early in the 16th century the serpentin or lever to hold the burning match was invented, and the match-lock quickly followed. In the best *matchlocks* the flash-pan was covered with a hinged lid, and the serpentin was forcibly thrown upon the touch powder in the flash-pan by a spring; but in the ordinary types the burning slow match was made to descend by pulling the lower end of the serpentin towards the stock. From the matchlock arquebus came the hagbut, hackbutt, hackenbuse, and the musket, which was originally a heavier weapon, and carried a double bullet. These early firearms were loaded with difficulty; at Kissingen in 1636, and at Wittenmergen in 1638, the musketeers fired seven shots in eight hours, which is accounted for by the fact that musketeers were harassed by the opposing cavalry

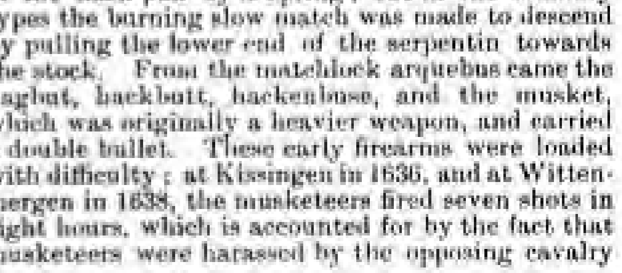


Fig. 6.—Early Matchlock-gun.

and archers, and that the loading had to be effected whilst the forked-rest was attached to the wrist by a short thong, and the soldier 'in skirmish doth charge his musquet afresh, and train his forke or staffe after him.' The matches of slow burning fuse, even when carried in the hat, or in a perforated metal case at the girdle, gave much trouble, especially in wet and foggy weather, and at the battle of Dunbar (1650) the English musketeers were unable to retain their fire on account of the weather. The *wheel-lock* originated from a gun in which pieces of pyrites were placed near the flash-pan, and the igniting spark was produced by the friction of a file rubbed against them. In the wheel-lock the flint is held in the flash-pan by a spring pressing against the opposite extremity of the lever to the one in which the flint is fixed; in the flash-pan is a grooved wheel with serrated edges, which is rapidly rotated by a chain and flat or V spring, or as is the drum of a watch. The wheel was wound up as in a watch, with a movable key, and was released upon the trigger being pulled; its rapid rotation against the flint firmly pressing upon it produced a stream of sparks instantly, and made ignition more certain. The wheel-lock was produced in Germany early in the latter half of the 16th century, and with its introduction the use of firearms for sporting purposes became more general.

The *firelock* or flintlock, more common than the expensive wheel-lock, was produced in Spain about 1625, as a cheap substitute for the wheel-lock. In the flintlock the *hammer* or cover-plate to the flash-pan is knocked backwards by the blow of the flint screwed in the jaws of the *cock*, and, uncovering the priming in the flash-pan, exposes the touch powder to the sparks produced by the flint grating against the steel face of the hammer. The early flintlock was clumsy, simple, and inefficient; it is said to have been produced by marauders, to whom the burning match of the arquebus was dangerous as betraying their presence; and, roughly made, it did not answer as a military weapon so

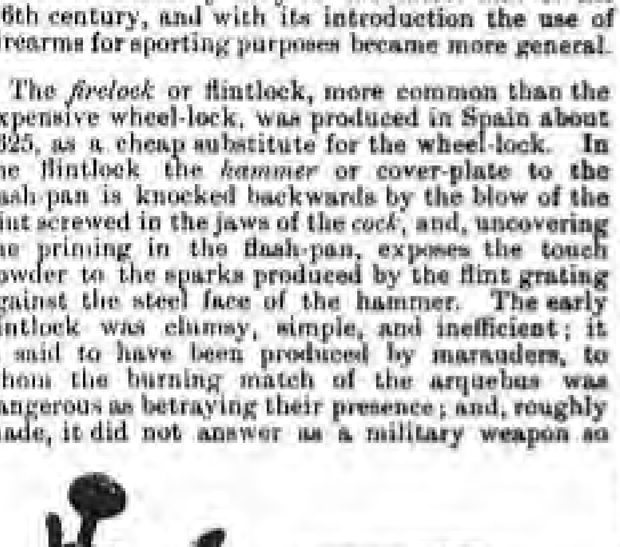


Fig. 7.
French Flintlock Breech-loader, 18th century.

well as the matchlock. Improvements in the latter half of the 17th century caused its more general adoption. It was common in the Netherlands, and was introduced into the English army in the reign of William III., and remained in use until 1840; the last firelocks supplied to the British government were for use abroad, and were made in 1842. The firelock or flintlock musket is still an article of commerce, as it can be used wherever there is a supply of powder and lead. The flint-lock in its highest degree of perfection was manufactured in London as a double sporting weapon at the beginning of the 19th century.

Pistols were developed from the small hand cannon termed 'poitrinal,' and were made in 1540 by Camillio Vettelli at Pistoia. They were used as *concealed* weapons, the German Ritters being the first to adopt them for military purposes. At the battle of Renty in 1554 the Ritters defeated the French through a manœuvre termed 'caracole,' in which the pistols played the most important rôle. The pistols, from having short barrels and heavy, clumsy butts, improved into successful cavalry arms when furnished with wheel-locks, and they were generally adopted as an auxiliary weapon. Double and four-barrelled pistols were common in the 18th century, and the revolving pistol, termed the 'pepper-box,' preceded the introduction of the modern revolver by Colonel Colt (see REVOLVER).

As a triumph of handicraft and exact workmanship the duelling pistol is without a rival, and the twenty-pace pistols firing a large bullet with a small charge of powder, as made in Paris at the present time, are not to be equalled as weapons of precision by any firearm extant. The revolver has superseded the pistol entirely for military and police purposes in civilised countries, but the revolver will in its turn have to make way for a magazine or repeating pistol.

Many of the early cannon hand-forged from rings and bars were breech-loading, the system employed being that of the movable breech-block, secured in position during the discharge by hammer-driven wedges; or a through pin uniting the block with the breech frame of the cannon. Such weapons date from the 14th century, and similar weapons formed part of the equipment of the *Mary Rose*, which foundered about 1545. Small-arms intended for the use of illustrious persons were occasionally made breech-loading. In the Tower collection is a musket which closely resembles the modern Snider in its breech mechanism, and this remarkable specimen of an efficient breech-loader is said to have belonged to Henry VIII., whilst several other varieties of arms having a movable breech-block were made prior to his reign. Small-arms and cannon with detachable breech-plugs—in which the charge was placed and fired—were made in the 16th century, and before its close breech-loaders with hinged barrels had been introduced. The hinge was usually at the joint, as in the weapon illustrated (fig. 7), and not a couple of inches forward of it, as in the Lefaucheux and other modern developments of the sporting gun. The 17th and 18th centuries were particularly prolific in the production of breech-loading mechanisms, but, owing to the absence of a cartridge containing its own ignition, none were successful until revived after the introduction of the percussion cap.

Amongst the early manufacturers of arms who aided the development by their handicraft or invention the Italian and Spanish smiths deserve mention; the accurately forged barrels of Nicolas Bis, and the fine workmanship on the pistols of the Comminazzo family, cannot be surpassed. Kollner of Vienna, and Kotter of Nuremberg, produced rifling; and Lazarino, Dax, and Nereiter improved the appearance and handiness, and added to the utility of firearms by minor inventions. The wheel-locks were neither manufactured nor used extensively out of Germany and Italy, but the Saxon collection in the Dresden Museum indicates the importance with which the invention was once regarded. The most curious arms were manufactured in Paris, Amsterdam, Hanover, Liége, and Lisbon, and later at the Moscow arsenal.

That necessity is the mother of invention has never been more truthfully demonstrated than by the development of firearms. The wars in Flanders and Germany during the middle ages quickened the genius of their inventors and improved the skill of their armourers; just as the tension in mid-Europe since the war of 1870–71 has given to France and Germany the finest repeating rifles and best artillery; whilst the leisure and taste of the Englishman has called for the finest sporting weapons. The invention of rifling in Germany in the 15th century led to the development of weapons of precision, the highest degree of accuracy being attained by a heavy muzzle-loading small-bore rifle with a high trajectory. The requirements of the military firearm—lightness, ease and quickness of manipulation, extreme range and great velocity, have led to the sacrifice of precision for the advantages possessed by light breech-loading arms (see BREECH-LOADING, and RIFLES).

Of the inventions which have been applicable to all firearms the most important has to do with the *ignition* of the charge of explosive. Fulminating or detonating powders were made by the French chemists of the 18th century; and about 1800 an Englishman, benefiting by their experiments, produced a highly sensitive explosive, composed of fulminate of mercury and saltpetre, which possessed all the requisite qualities of a priming powder for the flintlock firearms. In 1807 Alexander J. Forsyth, a Scottish clergyman, patented the application of the detonating principle for exploding gun-powder in firearms. Many inventors claimed the copper percussion-cap which followed and was first made in England in 1818, its introduction leading to the abandonment of the firelock. The expansive bullet, invented by Greener and improved by Minié, increased the range and accuracy of rifles, and made an accurate breech-loading rifle possible. The cartridge-case containing its own means of ignition, or the percussion-cap, is a French invention improved by Lefaucheux, Lancaster, Needham, Pottet, and others, and to it is due the success of modern breech-loading small-arms, this cartridge-case of solid drawn brass being used for all quick-firing machine guns and some of the smaller cannon. The expansion of the case at the moment of discharge causes it to act as an obturator and block all escape of gas into the breech-loading mechanism, whilst its contraction after firing admits of its being withdrawn with ease.

Sporting firearms consist of the shot-gun and the rifle for large game shooting. The use of hail-shot became general in Germany in the 16th century, and with the introduction of the wheel-lock the use of the arquebus for sporting purposes became more common. The earliest double-barrelled guns were made for military purposes, but sporting guns with two barrels side by side were made in Italy in the 17th century, and the art of shooting on the wing was first practised about 1580. The introduction of better forged barrels in the latter half of the 18th century made a light double-barrelled fowling-piece a possibility, and since then shot-gun barrels made of iron and steel fragments (1798) and twisted scelps (1806) have increased in strength and lightness. Old horseshoe nails and scraps of iron and steel were made into shot-gun barrels; but after 1850 new metal was employed and is now preferred. As the fowling-piece with hand-welded barrels made of twisted rods became more general, the supremacy of continental gun-makers over the English was lessened, and early in the present century the improvements made by Manton, Nock, Cook, Egg, and others placed English guns ahead of all competitors. The French invention of composite cartridge-case and breech-loading was turned to practical account by the English, who have unceasingly improved upon the original idea. In addition to the breech-loading mechanism, the shot-gun has been improved in range by the use of choke-boring—i.e. the constriction of the barrel at the muzzle; in safety, by the rebounding lock, which again has been superseded by various hammerless locks, or arrangement of the firing mechanism within the head of the gun; and in self-ejecting mechanism.

The sporting rifle is a type of firearm evolved from the wheel-lock hunting weapons of Germany. Its production is proof of the adaptability of fire-arms to special needs; the desiderata of a weapon for large game hunting include the quick firing of a second shot, and a paralysing effect from the penetration of the bullet. The repeating rifle cannot be twice fired as quickly as the double rifle, and length of range with a light ammunition and continuous quick firing are points sought in a military weapon. Precision is dependent upon the weight of the projectile being sufficient to maintain the direction imparted to it during its passage through the barrel. The bullet is helped to do this by the rifling giving the projectile a rotary motion, which equalises irregularities in the bullet, and lessens its tendency to deflect. The greater the velocity, the less quickly must the rifling turn; but with improved solid bullets, covered with nickel or steel, it is possible to get the bullet to grip the rifling at a velocity of 2000 feet per second, and a complete turn is made in ten inches, in which case the bullet has a double rotary motion and takes a corkscrew flight. The modern sporting or express rifle, as it is termed, fires a hollow expansive bullet at a high velocity for a few hundred yards, accuracy and range being sacrificed to force at impact. The average muzzle velocity of the military rifle is 1500 feet per second, of the express 2000 feet per second; and although with new ammunition and improved explosives the latest military rifle attains this initial velocity, the force of the bullet on impact does not approach that of the sporting rifle projectile. The smallest sporting rifle fires a bullet of about 120 grains, and the largest a bullet of 1600 grains (see RIFLES). Firearms are also used for a variety of secondary purposes: for the firing of signal shells at sea (in lieu of rockets), shooting oil-filled vessels from ships to prevent the breaking of the waves in stormy weather, for firing harpoons with a line attached, as used in whale and narwhal fishing, &c.

In the manufacture of early firearms the smith was the first and last workman. The Italians were amongst the first to ornament firearms, and finish them by chiselling, chasing, and engraving, as the Spaniards were amongst the first to supplement the work of the smith by filing and smoothing the exterior of the weapons, and polishing the interior of the barrels. For the last three centuries the most skilled handicraftsmen of Europe have been employed in the making or beautifying of firearms, and at the present day the manufacture of sporting guns remains essentially a handicraft, the mechanical processes having but lightened the labour of the workman, not superseded him. Some 20,000 workmen are now employed in Europe in the manufacture of sporting guns, the chief centres being Birmingham, Liége, and Prague, whilst the machine factories of Europe, together with the government arsenals engaged in making small-arms, employ a much larger number. In addition to the places mentioned, at Suhl, St Etienne, Steyr, and Tula, and at Springfield, Hartford, and elsewhere in the United States, large numbers of firearms are made yearly. The idea of making army muskets with interchangeable parts originated with the French about a century ago, but the only successful result was the 'drop forging' or stamping out of the various limbs, and about 1797 Whitney made some 10,000 muskets in America from stampings, and used improved machinery in finishing the parts.

The perfecting of the machinery for the manufacture of interchangeable arms is the work of Hall, of Harper's Ferry, U.S., whose system was adopted in government workshops in 1818; and of Blanchard, whose improved lathes produced interchangeable stocks. The system of making firearms by machinery was introduced into England in 1856, since which date many futile attempts have been made in various countries to produce fine sporting arms wholly by machinery.

The improvements immediately sought in firearms are such as will tend to simplify or strengthen the breech-loading mechanism (see BREECH-LOADING), and to strengthen and at the same time lighten the barrel; the discovery of a material stronger than steel; and such inventions as will increase the range or precision of the weapon or lessen its recoil. For the capabilities of various weapons, see CANNON, RIFLES, REVOLVERS, &c.

The best military small-arms—rifles—are available to a range of 2000 yards, and the best express to 300 yards. A match-rifle will fire with a mean deviation of 1·75 feet or less at 1000 yards range, and a shot-gun will put upwards of two-thirds of its charge of shot into a circle thirty inches in diameter at 40 yards range, and the last shot of the charge will not be more than ten feet behind the first one that reaches the target at that distance. The killing range of the average shot-gun is about 45 yards, of wild-fowling guns with swan shot 140 yards. After the pulling of the trigger, until the charge of shot reaches the muzzle, ·007 of a second elapses, and ·13 before the shot, having passed the muzzle, strikes the target 120 feet distant.

Fireball is the popular name of projectiles, other than rockets, which are used for incendiary or illuminating purposes. They are more properly called *carcasses*, or *ground* and *parachute light-balls*. The carcass is a thick shell filled with fiercely burning composition, and having large holes, or vents, out of which this streams. The ground light-ball is filled with brightly burning composition, and burns on the ground. The parachute shell is fired from a mortar, and fuzed so as to open in the air and support, by means of a parachute packed inside it, a pan of brightly burning composition. The electric light has superseded these last two, and the rocket the first.

Fireclay is the variety of clay which is used for the manufacture of firebricks, gas-retorts, crucibles, glass pots, chimney-pipes, and other articles, most of which require to resist the action of high and long-continued heat. Ordinary fireclay is chiefly found in beds not usually much exceeding two feet in thickness, in the coal-measures, interstratified with seams of coal and other rocks. In the British Islands it is most largely worked about Glasgow, Newcastle-on-Tyne, and Stourbridge in Worcestershire, at which last place it is said to have been discovered about 1555 by some wandering glassmakers from Lorraine. But it occurs, more or less, in most places where true coal is found. It is mined in Germany, Belgium, France, the United States, and other countries. Stourbridge fireclay, owing to its excellent quality, is largely exported to foreign countries, as well as bricks and other objects made of it. Refractory clays are found, though more rarely, in other formations besides the coal-measures. For example, some of Tertiary age found in Dorsetshire and Devonshire are made into firebricks. The following table shows the principal constituents of fireclay:

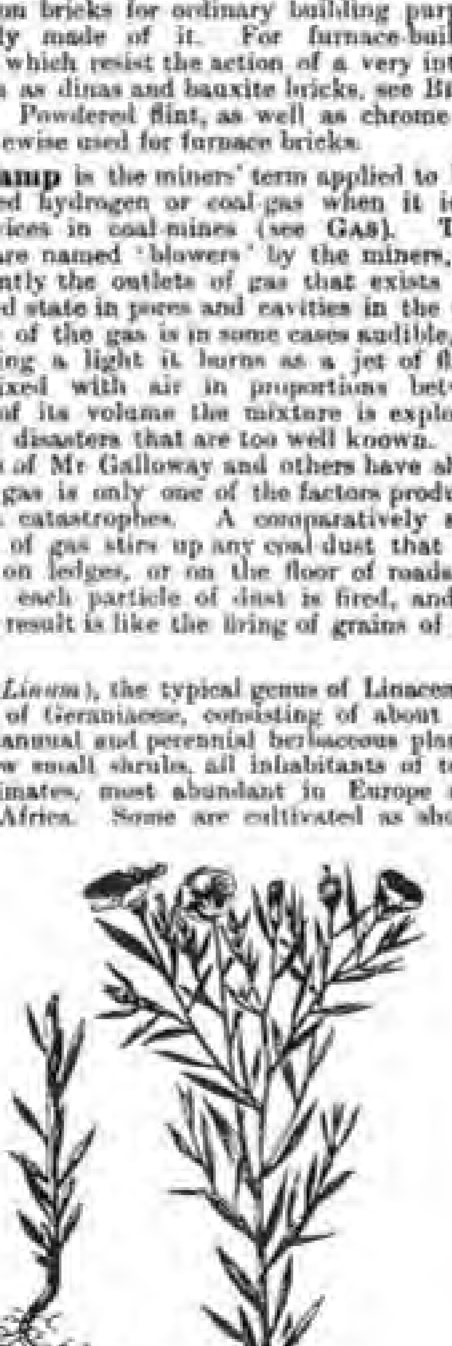
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Silica	65·10	51·10	56·49	53·52	54·29
Alumina	22·22	31·35	28·95	33·68	33·80
Potash	·18	...	...	trace	trace
Lime	·14	1·46	trace	·76	trace
Magnesia	·18	1·34	...	·14	·02
Oxide of Iron	1·92	4·63	1·05	·32	·01
Water	9·28	10·47	11·05	11·34	10·86
Organic Matter	·58		...	..	·15

No. 1, Stourbridge; No. 2, Newcastle-on-Tyne; No. 3, Gartsherrie, Scotland; No. 4, Poole, Dorsetshire; No. 5, Morgantown, West Virginia, United States. See CLAY.

Fireclays from the same locality often differ considerably in their composition and quality. Some of the Newcastle clays, for example, contain from 70 to 80 per cent. of silica with from 9 to 18 per cent. of alumina. A high percentage of silica and alumina together (their relative proportions being comparatively immaterial) and small quantities of alkaline substances and oxide of iron constitute a refractory fireclay. If not small in amount, alkaline bodies in the clay tend to make it easily fusible, so that bricks formed of it are apt to soften and yield in a furnace. Fireclays are generally yellow in colour after being fired in the kiln. No very sharp line of distinction can be drawn between hard infusible clays and softer marly clays used for terra-cotta, garden vases, and some kinds of house bricks. In districts where fireclay is abundant composition bricks for ordinary building purposes are partly made of it. For furnace-building materials which resist the action of a very intense heat, such as dinas and bauxite bricks, see BRICK-MAKING. Powdered flint, as well as chrome iron ore, is likewise used for furnace bricks.

Firedamp is the miners' term applied to light carburetted hydrogen or coal-gas when it issues from crevices in coal-mines (see GAS). These crevices are named 'blowers' by the miners, and are evidently the outlets of gas that exists in a compressed state in pores and cavities in the coal. The issue of the gas is in some cases audible, and on applying a light it burns as a jet of flame. When mixed with air in proportions between $\frac{1}{4}$ to $\frac{1}{30}$ of its volume the mixture is explosive, producing disasters that are too well known. The researches of Mr Galloway and others have shown that the gas is only one of the factors producing the worst catastrophes. A comparatively small explosion of gas stirs up any coal-dust that may be lying on ledges, or on the floor of roads and workings, each particle of dust is fired, and the combined result is like the firing of grains of gunpowder.

Flax (*Linum*), the typical genus of Linaceæ, a sub-order of Geraniaceæ, consisting of about 140 species of annual and perennial herbaceous plants, with a few small shrubs, all inhabitants of temperate climates, most abundant in Europe and northern Africa. Some are cultivated as showy



Common Flax (*Linum usitatissimum*).

garden annuals—e.g. *Linum grandiflorum*, &c., while the allied *Radiola millegrana* (Allseed) is the smallest of our phanerogamic weeds. *L. catharticum*, an annual weed, is the Purging Flax, long a standard resource of domestic medicine. But all essential interests centre round the Common Lint or Flax, well named by Linnæus *L. usitatissimum*, since in its importance for civilised man it rivals the staple food plants. There are two main varieties or sub-species—*vulgare* and *crepitans*, the latter distinguished by its shorter and more branched stems and rather larger leaves, but more easily by its larger capsules, which burst open when ripe with a characteristic sound, so scattering the seed. Though shorter, this yields the finer, softer, and whiter fibre. In both the flower is a loose corymb of beautiful blue flowers. *L. austriacum* is also cultivated in France, *L. maritimum* in southern Europe, and *L. Lewisii* in North America, but all yield a coarser fibre. The flax of prehistoric times found in the Swiss pile-dwellings, and in the remains of the stone age in northern Italy, was derived from *L. angustifolium*, as not only the manufactured product but the actual remains of the stems, fruit, and seeds clearly show. The common lint of the Aryan peoples was, however, *L. usitatissimum*, and the occurrence of the name lint with little modification in all European languages is usually interpreted as indicating that its use dates from the remote antiquity of their common home. The same culture is shown by an examination of the mummy-cloths of Egypt, which are always of linen; and the species is also recognisably delineated upon the walls of the tombs.

For an account of the mode of preparation of its bast as a textile fibre, see below; for processes of manufacture, see LINEN; and for a description of the useful applications of its seed, see LINSEED, OILCAKE, OIL.

FLAX-DRESSING.—Growing stems of flax are not cut by scythe or reaping-machine, but pulled up by the roots. The best time for doing this is when the stalks begin to turn yellow at the base, and the seeds begin to change from green to a pale brown. A heavier crop is obtained when the plant is riper, but the quality of the fibre is injured. It is of importance that the stems of equal length should be separated, uniformity in this respect simplifying the dressing processes.

Rippling, the process of removing the seeds, follows the harvesting. The ripple, or rippling-comb, consists of a row of round iron teeth set in a wooden frame which is fixed to a plank. In length the teeth are about 18 inches, and at the pointed tops they are about half an inch apart. The rippler, taking up a bundle of flax, spreads out the tops like a fan, and generally draws first the one half of it and then the other through the teeth, a sheet being placed on the ground to receive the seeds or bolls as they fall. One or two machines have been introduced for rippling flax. One of these removes the seeds by passing the stems between two cast-iron cylinders. Another performs the operation by means of beaters which loosen the seeds, and shakers which then shake them out of the bundles of flax-straw.

Retting is the name given to the next process in the treatment of the stems of flax. Its object is to facilitate the separation of the useful fibre from the boon or woody part of the stem through the removal, by fermentation, of the gummy or resinous matters present in the plant. This is done either by dew-retting or by water-retting with or without the aid of heat. Dew-retting consists in spreading the flax on the grass, and exposing it to the influence of dew, rain, air, and light for a considerable time. It is a method practised in Russia, and produces a soft and silky fibre. Water-retting or steeping is the plan most generally followed. Soft water is essential, and the dam or pond should not be more than four feet deep. In this the flax bundles or 'beets' are placed in rows, roots downwards, and then covered with weeds or straw weighted with boards and stones, or with turf and stones, to keep the flax below the water. If the weather is warm fermentation begins soon, a change which causes the flax to rise in the water, and it must then be more heavily weighted. The flax sinks again as the fermentation slackens, the extra weight being then removed. Great judgment is required to determine when the retting has proceeded far enough. The stems are examined with much care, and if one finds on breaking them at one or two places, or twisting them in the middle in opposite directions, that the woody core called 'shore' or 'shive' separates freely from the fibre, the flax is ready for removal from the pond. From ten to fourteen days are required for the process with water at ordinary temperatures. The smell that accompanies the process is most offensive, and water in which flax has been steeped is valuable as a liquid manure.

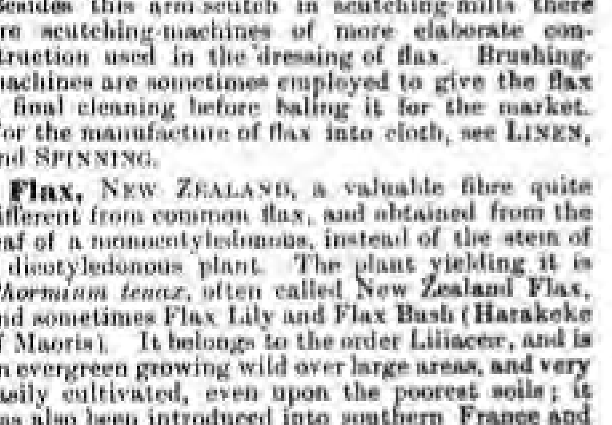
A quicker process of retting, in which water at a temperature of 75° to 90° F. is used, was introduced by an American, R. B. Schenck, in 1847. Wooden vats are employed, and the fermentation goes on so much more rapidly that the time of steeping is reduced to from 50 to 60 hours. By another invention (Pownall's) the flax is passed between heavy rollers after it is taken from the vats, clean water being kept flowing over the stems during the operation to remove the gummy matters. Schenck's method is not much favoured now.

Grassing follows the ordinary retting process. The flax stems are spread in rows of thin layers upon short grass for a few days, during which time they are sometimes turned with a pole; but if this is not done, the tips of the stems of one row should overlap the root ends of the next. The flax is lifted when it is found that a slight rubbing suffices to separate the woody core from the fibre.

Breaking.—After the retted stems are dried they undergo 'breaking' to prepare them for the scutching process. One simple and efficient machine for breaking consists of two pairs of horizontal fluted rollers—one pair having finer flutes than the other—mounted in a frame, and turned by the necessary gearing. There is also a feed-table. In passing between the rollers the brittle woody parts of the stems are broken throughout their length. Later breaking-machines have more numerous fluted rollers, some of which have a reciprocating motion. The more efficiently the breaking is performed the less will be the amount of scutching required.

Scutching.—The woody matter of the flax stems being broken up and ready to be separated from the fibrous portion, this is done either by hand-scutching or, as is chiefly now the case, by scutching-machines. In the hand-process the flax is hung up in such a position that it can be struck repeatedly with the blade of a scutching-knife, so as entirely to remove the woody portion. In scutching-mills—which are usually driven by water-power—the scutching is performed by a series of vertical wheels, on each of which are mounted a few wooden blades projecting considerably beyond the rim. These blades take the place of the scutching-knife, and work against wedge-shaped projections in a partition, striking the flax in the direction of its length, a workman sliding the 'broken' flax gradually forward as the scutching proceeds. Besides this arm-scutch in scutching-mills there are scutching-machines of more elaborate construction used in the dressing of flax. Brushing-machines are sometimes employed to give the flax a final cleaning before baling it for the market. For the manufacture of flax into cloth, see LINEN, and SPINNING.

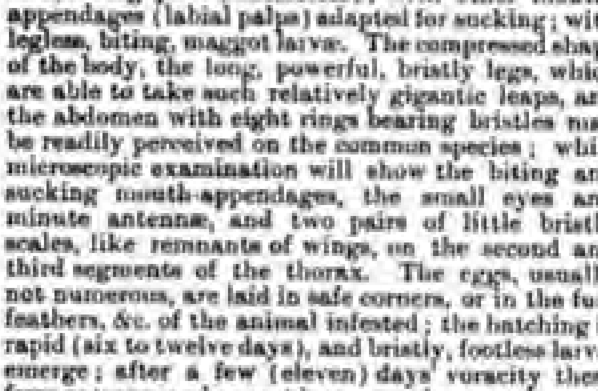
Flax, NEW ZEALAND, a valuable fibre quite different from common flax, and obtained from the leaf of a monocotyledonous, instead of the stem of a dicotyledonous plant. The plant yielding it is *Phormium tenax*, often called New Zealand Flax, and sometimes Flax Lily and Flax Bush (Harakeke of Maoris). It belongs to the order Liliaceæ, and is an evergreen growing wild over large areas, and very easily cultivated, even upon the poorest soils; it has also been introduced into southern France and Dalmatia, and is familiar in colder climates as



New Zealand Flax (*Phormium tenax*):
a, inflorescence; *b*, separate flowers, enlarged.

a decorative plant in greenhouses and sheltered gardens. Its leaves resemble those of an Iris, and are from two to six feet long and one to two or three inches broad. The flowers are produced in a tall branched panicle, and are numerous, brownish-yellow, and not very beautiful; the fruit is a three-cornered capsule, with numerous compressed jet-black seeds. The fibre of the leaves is both very fine and very strong, and was used by the New Zealanders, before their country was discovered by Europeans, for making dresses, ropes, twine, mats, cloth, &c. New-Zealand flax is imported into Britain for making twine, ropes, sailcloth, and other uses to which its strength and durability alike well adapt it. To obtain the fibre the leaves are cut thrice yearly, and the fibre is easily separated by maceration. But the New Zealanders procure the fibre in its greatest perfection, very long and slender, shining like silk, by a more laborious process, and without maceration, removing the epidermis from the leaf when newly cut, separating the fibres by the thumb-nails, and then more perfectly by a comb. The root-stocks are bitter and purgative, and have been used as a substitute for sarsaparilla. The leaves, when cut near the root, exude a viscid juice, which becomes thick and gummy, and is then eaten; the New Zealanders prepare a sweet beverage from the flowers.

Flea, a name applicable to any member of the small order Siphonaptera or Aphaniptera, of which *Pulex irritans* is a familiar example. They are wingless insects, probably related to flies; with saw-like, biting jaws (mandibles); with other mouth-appendages (labial palps) adapted for sucking; with legless, biting, maggot larvæ. The compressed shape of the body, the long, powerful, bristly legs, which are able to take such relatively gigantic leaps, and the abdomen with eight rings bearing bristles may be readily perceived on the common species; while microscopic examination will show the biting and sucking mouth-appendages, the small eyes and minute antennæ, and two pairs of little bristly scales, like remnants of wings, on the second and third segments of the thorax. The eggs, usually not numerous, are laid in safe corners, or in the fur, feathers, &c. of the animal infested; the hatching is rapid (six to twelve days), and bristly, footless larvæ emerge; after a few (eleven) days' voracity these form cocoons, and so rest in pupa quiescence for variable periods. In summer the entire development of *Pulex irritans* occupies about a month. The fleas



Metamorphoses of Common Flea (*Pulex irritans*), magnified:
a, larva; *b*, pupa or nymph; *c*, perfect insect.

are all ectoparasitic on warm-blooded animals, and the numerous species are more or less rigidly confined to diverse furred and feathered hosts. The common flea (*Pulex irritans*) is sometimes regarded as the only species of the genus Pulex, and the others are ranked as species of Ceratopsyllus, &c.; but this seems rather in honour of man as being the host of the first-named flea than from any real difference. It seems probable that the flea of the dog is an intermediate host of a tapeworm common in that animal. The muscular energy of these pests has been utilised in 'flea-exhibitions,' in which tamed captives drag miniature carriages, and perform similar exercises. As regards their leaping powers, Kirby and Spence have the following note: 'Aristophanes, in order to make the great and good Athenian philosopher, Socrates, appear ridiculous, represents him as having measured the leap of a flea. In our better times scientific men have done this without being laughed at for it, and have ascertained that, comparatively, it equalled that of the locust, being also two hundred times its (the flea's) length.' Where fleas prevail in spite of cleanliness, recourse may be had to insecticide preparations, the modern substitutes for the old-fashioned fleabane and wormwood. According to Tusser, 'where chamber is swept and wormwood is strown, no flea fo his life dare abide to be known.'

Fleabane (*Pulicaria*), a genus of Compositæ (sub-order Tubuliflorae, family Inuleæ), readily recognised by a peculiar aromatic smell, sometimes compared to that of soap, which is said to be efficacious in driving away fleas. There are two British species, *P. vulgaris* and *P. dysenterica*, and the latter has a considerable reputation in diarrhœa and dysentery. *Conyza squarrosa*, also called fleabane, belongs to a closely allied genus.

Fluorescence is the term applied to a peculiar blue appearance exhibited by certain substances exposed to sunlight, and especially observable in a dilute solution of sulphate of quinine. See PHOSPHORESCENCE.

Fluorine (sym. F, eq. 19) is an elementary substance allied to chlorine. Its principal natural source is the mineral fluor spar, CaF, although it is also found in minute quantities in the igneous rocks, natural waters, plants, the bones and teeth of animals, as also in milk, blood, &c. All attempts to isolate fluorine in vessels of glass, gold, platinum, &c. have failed owing to its powerful action on these substances and the readiness with which it forms compounds with them. Recently, however, a vessel of an alloy of platinum and iridium has been used, and the pure substance obtained (1888). It is a gas having properties similar to those of chlorine, but differing in energy of action. The compounds of fluorine are not numerous, but are important. *Hydrofluoric acid*, HF, is generally prepared by heating gently in a lead still a mixture of one part of fluor spar, CaF_2, with two parts of sulphuric acid, H_2SO_4, when the vapours of hydrofluoric acid, HF, are evolved, whilst sulphate of lime, $CaSO_4$, is left in the still. The dense acid vapours are conducted through a lead pipe into a lead receiver or bottle surrounded by a freezing mixture of ice and common salt. The acid is generally mixed with water when desired to be kept for some time. When the most concentrated hydrofluoric acid is required, the still and receiving vessel must be made of platinum. The other metals are not suitable for such apparatus, as they are rapidly corroded by the acid. When prepared in its strongest form, hydrofluoric acid has the density of 1·060, and is a colourless, fuming liquid of great volatility, which boils at 60° (15·5° C.). Not only does hydrofluoric acid corrode and dissolve the ordinary metals (excepting lead and platinum), but when placed on the skin it produces a severe burn owing to its caustic nature. The most important property which hydrofluoric acid possesses is its power of eating into and dissolving glass, which admits of its application in the etching of characters upon glass, as in thermometer tubes, and for eating away greater or less thicknesses of plates or sheets of coloured glass, so as to produce a variety of shades. See GLASS, and GLASS-PAINTING.

Fluorotype, a photographic process in which salts of fluoric acid were employed for the purpose of producing images in the camera; but, as the impression was not very strong, the plate had to be afterwards steeped in a weak solution of protosulphate of iron. The process was first suggested by Robert Hunt in 1844.

Fly Poison. This term includes the various preparations which are sold for the purpose of killing flies. Formerly powders on papers containing arsenic, and sweetened so as to attract the flies, were in general use. Since it has been found that paper dipped into a sweetened solution of quassia is equally efficacious, the poisonous article has been partly superseded. Under this heading may be included various viscid substances which, when smeared on threads or on boards, attract flies by their sweetness, and retain them by their stickiness. For this purpose treacle and birdlime are fairly effective.

Fly-wheel, a large wheel with a heavy rim fitted to steam-engines, or other machinery, in order to equalise the effect of the driving effort. Its action depends on the principle that matter in motion possesses kinetic energy—e.g. a body in having its velocity reduced is capable of doing work. The amount of work it can do depends directly on the mass of the body, and on the difference of the squares of its initial and final velocities, and is numerically equal to $\frac{m(v_1^2 - v_2^2)}{2}$. A heavy wheel thus becomes a reservoir of work when set in motion.

There are two principal cases in which the fly-wheel is commonly applied: (1) where the driving effort is intermittent or irregular, while the resistance to be overcome is for the time practically constant; and (2) where the resistance or work to be done is intermittent or irregular. The crank in a foot-lathe is a good example of the first case; the driving effort of the foot is only applied to the treadle on the down stroke, and the crank must rise independently of the effort. A fly-wheel attached to the crank-shaft effects this, the motion it acquires while the foot is acting gives it energy, and in virtue of this it is able to bring the crank up again into the proper position for the foot to act on the treadle. In single-crank engines the fly-wheel carries the crank over the dead centres (see CRANK), and whenever used in engines its function is to keep the speed steady during each revolution of the crank—i.e. to prevent unsteadiness during each turn; this it does by storing up energy during parts of the revolution when the effort is greater than the mean resistance, and giving it up again during those parts of the revolution when the effort falls below the resistance. In the gas-engine, where the effort (explosion) is often only applied during part of every second or third revolution, it does very important work. Its action must be clearly separated from that of the governor, whose function is to determine the mean speed or number of turns the engine shall make per minute; this the fly-wheel cannot in any way do—it can only keep the speed steady during each turn.

The second case is illustrated by a punching-machine. The engine need not be of sufficient power to directly force the punch through the metal, but with the aid of a fly-wheel it easily does it. The machine is so arranged that the actual part of each revolution spent in punching is very small; all the rest of the revolution the fly-wheel is storing up energy, nearly all the effort going in this. Then at the proper moment the work stored up is added to the direct work of the engine, and the punch forced through, the speed of the fly-wheel being proportionately reduced.

The principle of the fly-wheel is sometimes applied in other forms than that of a wheel—e.g. in fly-presses for stamping or coining metals, in which two heavy balls are fixed at the ends of a long lever, which is made to swing round with considerable velocity. The accumulated energy is given up at the moment of impact of the die upon the metal, and a force of great intensity called into play to compress the latter. Fly-wheels are not required in locomotives or marine engines (see STEAM-ENGINE).

Foil (Lat. *folium*, 'a leaf') consists of metal reduced to very thin sheets, intermediate between the extremely thin leaf metal, such as gold and silver leaf, and sheet metal. There are two distinct classes of foil in common use—the foil which in tenuity approaches leaf metal, and the much stouter tinsel foil used by jewellers, and for theatrical ornaments, &c.

Tinfoil is made by rolling bars of tin down to fine sheets, which are further attenuated by being laid in piles and beaten with a wooden mallet. Formerly tinfoil was very largely used for the 'silvering' of mirrors, by amalgamation with mercury; but that process is now little employed (see MIRROR). The chief consumption of tinfoil is now in connection with the wrapping up of chocolate and other confectionery, and of tobacco and other products which must be kept from drying in the air. It is also largely used for lining small boxes and cases, and in the preparation of Leyden jars and other electrical apparatus.

The bright foil used by jewellers and for theatrical and other ornaments, under the name of 'tinsel,' is made of copper, tin, tinned copper, or silvered copper. The last is now chiefly used by jewellers. The metal is rolled in a flatting mill, and the requisite brilliancy of surface is produced by finishing between burnished rollers and polishing. The various colours are produced by coating the white metal with transparent colours mixed in isinglass size. A similar varnish without colour is laid over the white foil, to prevent tarnishing. The socket or setting in which a stone or paste is mounted is lined with the foil, which, by reflecting from the internal facets the light that passes through the stone, adds considerably to its brilliancy. The natural colours of real stones are sometimes heightened or modified by coloured foil, and factitious colours are thus given to the glass or 'paste,' as it is called, of which spurious precious stones are made.

Fomentation (Lat. *fomentatio*, *fomentum*; from *foveo*, 'I warm'), an application of warmth and moisture to a part, by means of cloths wrung out of hot water, sometimes medicated with vegetable infusions of substances calculated to relieve pain or stimulate the surface. Thus, opium, belladonna, camomile, turpentine, &c. are used in various forms in connection with fomentations, which are employed in almost all painful local disorders. A fomentation can generally best be made by laying a strong towel across an empty basin, placing upon it a piece of flannel, folded to the proper size, pouring over this sufficient boiling water to wet it, and wringing it out inside the towel. It can thus be applied at once hotter and less wet than if it is wrung out by the hands alone. A sheet of waterproof material should be placed over it, to prevent wetting of the clothes, &c.; and another flannel substituted as soon as the first becomes cool.

Foot. In man the bones of the foot are twenty-six in number, and are arranged in three natural groups—viz. the tarsal bones, which are the hindermost; the metatarsal bones, which occupy the middle portion; and the phalanges of the toes anteriorly. The tarsal bones, seven in number, are short and somewhat cubical, and form the heel and the hinder part of the instep. The uppermost (see fig. 1) is called the *astragalus*, from its supposed resemblance to the dice used by the Romans. Above, it articulates with the two bones of the leg, the *tibia* and *fibula*, and through these bones the whole weight of the body is thrown upon the two *astragali*. Below, it is connected with and rests upon the *os calcis*, or heel-bone, which is the largest bone of the foot. Immediately in front of the astragalus, and supporting it in this direction, is the *scaphoid* or boat-like bone.

Fig. 1.—Bones of the Foot and Ankle:
a, tibia; b, fibula; c, astragalus; d, os calcis, or heel-bone; e, scaphoid bone; f, g, h, the internal, middle, and external cuneiform bones; i, cuboid bone.

In front of the scaphoid bone are the three *cuneiform* or wedge-shaped bones; and on the outer side of the cuneiform bones, and in front of the os calcis, is the *cuboid* bone. We see from fig. 1 that the front row of tarsal bones is composed of the three cuneiform bones on the inner side of the foot, and of the cuboid bone externally. There are five metatarsal bones passing forward, one for each toe. Each cuneiform bone is connected with one, and the cuboid bone with two, of these metatarsal bones. Behind, they are close together, but as they run forward they diverge slightly from one another, and their anterior ends rest upon the ground and form the *balls* of the toes. They constitute the forepart of the instep. The remaining bones are those of the toes, and are named the *phalanges*, each toe having three of these bones, excepting the great toe, which has only two. (A similar law holds for the bones of the hand, each finger having three phalanges, but the thumb only two.)

The instep is composed of the seven tarsal and the five metatarsal bones, which are so arranged and connected (see fig. 2) as to form the *plantar* arch from the extremity of the heel-bone to the balls of the toes. The astragalus forms the summit or keystone of this arch, and transmits the weight which it receives back to the heel, and forward to the balls of the toes.

The bones where they articulate with one another are covered with a tolerably thick layer of smooth cartilage, and by this means, together with the very slight movements of which each bone is

Fig. 2.
Section through the lower end of the tibia a, and through the astragalus b, the heel-bone c, the scaphoid bone d, the internal cuneiform bone e, and the bones of the great toe f.

capable, a degree of elasticity is given to the foot, and consequently to the step, which would be altogether wanting if the plantar arch were composed of one single mass of bone. This elasticity is far greater in the anterior pillar of the arch, which is composed of five comparatively long bones sloping gradually to the ground, than in the posterior pillar, which is short, narrow, and composed of a single bone, which descends almost vertically from the ankle to the ground. Hence, in jumping from a height, we always endeavour to alight upon the balls of the toes, and thus break the shock which we should feel if by accident we descended upon the heels.

The bones of the foot are held together by short ligamentous bands of great strength. These are attached to the non-articular surfaces of the bones, and are arranged mostly on their *plantar* and *dorsal*—i.e. upper—surfaces, while others are situated between bones, and are hence named *interosseous*. So resistant are these ligaments that it is almost impossible to dislocate the bones which they hold together.

The spot over which the inferior calcaneo-scaphoid ligament extends is the weakest in the foot, the astragalus being there unsupported by any bones; additional support is, however, afforded where it is more required by the tendon of a strong muscle, the *posterior tibial* (fig. 3, B), which passes from the back of the tibia (the chief bone of the leg) round the inner ankle, to be inserted into the lower part of the inner surface of the scaphoid bone. It not unfrequently happens that the astragalus, being either insufficiently supported, or from its being overweighted, descends slightly below its proper level, causing a lowering of the arch and a flattening of the sole of the foot. The defect when slight is known as 'weak ankle;' when more decided it is termed 'flat-foot;' and in extreme cases the bone may descend to such an extent as even to render the inner side of the foot convex when it naturally should be concave.

In the movements of the foot upon the leg we see a striking combination of variety of movement with general security. This combination is effected by the harmonious action of three joints, each of which acts in a direction different from the others. The first of these joints is the ankle-joint, which is formed by the bones of the leg—the tibia and fibula—above, and the astragalus below. At this joint the movements of *flexion*—i.e. approximation of the toes to the knee, and *extension*—i.e. pointing the toes to the ground, take place. The second joint is between the astragalus and the heel-bone, and it permits the foot to be rolled inwards or outwards; while the third joint is between the first and second row of tarsal bones—viz. between the astragalus and os calcis behind, and the scaphoid and cuboid bones in front—and allows the degree of curvature of the plantar arch to be increased or diminished within certain limits. The following is the order in which the movements of these three joints occur: the raising of the *heel* (by the first joint) is accompanied by a rolling of the foot *inwards* (by the second joint), and by an increased *flexure* of the plantar arch (by the third joint); and the raising of the *toes* is accompanied by a rolling of the foot *outwards*, and a *straightening* of the sole.

The joints, however, merely allow of movements; they do not effect them: this is the special function of the muscles; and each of the three movements we have indicated is effected by special groups of muscles. The principal of these muscles are shown diagrammatically in figs. 3 and 4, representing the inner and outer sides respectively. The first series of movements is mainly effected by three muscles: viz. (1) *muscles of the calf* (fig. 3, A), attached above to the bones of the thigh and leg, and below by the *Tendo Achillis* to the heel-bone; (2) the *posterior tibial* (fig. 3, B), attached above to the tibia, and below by its tendon to the scaphoid bone; and (3) the *short fibular* (fig. 4, C), attached above to the fibula, and below by its tendon to the outer metatarsal bone. The calf-muscles, whose tendon is inserted into the heel-bone, are large and very powerful, for in raising the heel they have to raise the weight of the body. The other two muscles, the posterior tibial and the short fibular, turn round the inner and the outer ankle respectively, and are inserted into the inner and the outer edges of the instep; the former being attached to the scaphoid, and the latter to the outer metatarsal bone. They not only assist in raising the ankle, but support it laterally. The muscle whose tendon is on the inner side of the foot (the posterior tibial) effects the two movements which are associated with the raising of the heel-bone—viz. the turning of the foot inwards and the increased flexure of the arch.

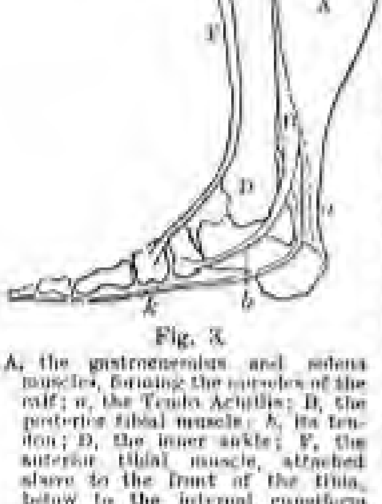


Fig. 3.

A, the gastrocnemius and soleus muscles, forming the muscles of the calf; a, the Tendo Achillis; B, the posterior tibial muscle; b, its tendon; D, the inner ankle; F, the anterior tibial muscle, attached above to the front of the tibia, below to the internal cuneiform bone; k, the flexor tendon of the great toe.

The second series of movements—the raising of the toes, the turning of the foot outwards, and the straightening of the sole—are effected by two muscles, the *anterior tibial* (fig. 3, F) and the *third fibular* (fig. 4, G), whose tendons pass, one in front of the inner ankle, and the other in front of the outer ankle, to the corresponding edges of the instep, and are inserted into the internal cuneiform and the outer metatarsal bones. These muscles are direct flexors of the tarsus upon the leg; the former raising the inner, and the latter the outer border of the foot.

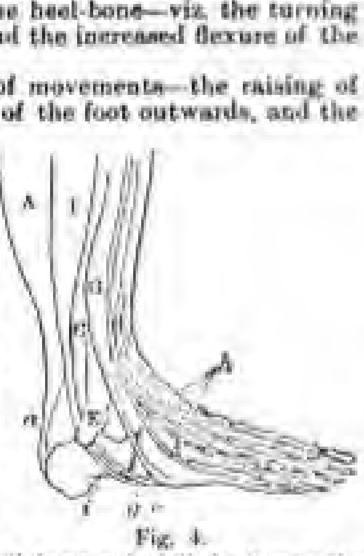


Fig. 4.

E, lower end of fibula, forming the outer ankle; C, the short fibular muscle, attached above to the fibula, and below by its tendon, c, to the outer metatarsal bone; I, the long fibular muscle, its tendon, i, running behind the outer ankle and under the instep to the metatarsal bone of the great toe; G, the anterior or third fibular muscle, attached above to the fibula and below by its tendon, g, to the outer metatarsal bone; h, the extensor tendons of the toes.

Another point in the anatomy of the foot that requires notice is the mode of union of the metatarsal with the tarsal bones. In these joints in the fourth and fifth toes a slight revolving motion can take place, which probably enables the outer metatarsals to adapt themselves to inequalities of the ground, and to equalise the distribution of the weight which is thrown upon the foot; while, in the corresponding joints of the three inner toes, scarcely any motion can occur—a provision by which additional strength is given to the inner side of the foot, upon which the weight of the body most directly falls.

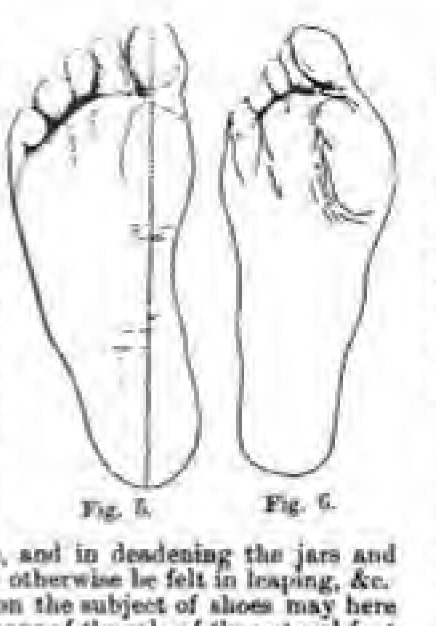


Fig. 5. Fig. 6.

The skin of the sole is very tough and strong; and intervening between it and the bones and the strong fascia of the sole of the foot is a thick pad of fat, which acts the part of an air or water cushion in defending the adjacent parts from injurious pressure, and in deadening the jars and shocks that would otherwise be felt in leaping, &c.

A few remarks on the subject of shoes may here be added. The shape of the sole of the natural foot is shown in fig. 5, while the shape after the prolonged use of a badly-made shoe is given in fig. 6. In the foot in its normal state the great toe is seen to be free from the others, and the line of its axis prolonged backwards passes through the centre of the heel; while in the foot distorted by the use of the shoe the line of the great toe is quite altered, and the toes generally—not being able to find room side by side—overlap each other and lose their separate and individual actions; corns, bunions, and ingrowing toe-nails being the natural consequence of this maltreatment. Meyer of Zurich drew attention to the bad treatment which the foot receives from ordinary shoemakers, and pointed out that the great toe should be allowed to have its normal position, and this can be done by making the inner edge of the sole incline *inwards*, instead of *outwards*, from the balls of the toes. The accompanying figure (7) gives the outline of a shoe designed under Meyer's superintendence, and shows the difference between it and the usual shape; the latter being indicated by the dotted outline. High heel-pieces tend to make the step less steady and secure, to break down the arch of the foot, to shorten it, and to impair the action of the calf-muscles. A high heel-piece, moreover, places the forepart of the foot at a lower level than the heel; the weight is thus thrown too much in the direction of the toes, and they are thrust forward and cramped against the upper leather of the shoe.

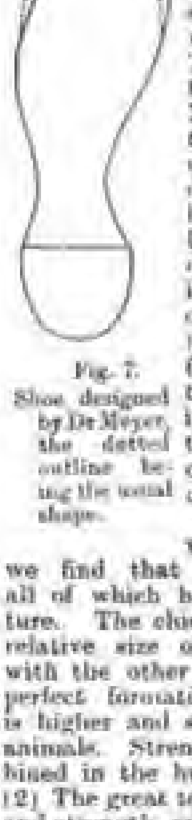


Fig. 7.
Shoe designed by Dr Meyer, the dotted outline being the usual shape.

If we compare the human foot with the feet of other mammals we find that it presents certain peculiarities, all of which have reference to man's erect posture. The chief peculiarities are (1) the greater relative size of the tarsal bones as compared with the other bones of the foot, and the more perfect formation of the plantar arch, which is higher and stronger than in any of the lower animals. Strength and elasticity are thus combined in the human foot in the highest degree. (2) The great toe is remarkable in man for its size and strength, and for the firm manner in which its metatarsal bone is joined to the other bones so as to render it the main support to the foot. (3) If we compare the human foot with that of the gorilla (fig. 8) or any other Anthropoid Ape (q.v.) we see that the toes are short and small in man in relation to the other parts of the foot, while in the gorilla the toes form the greater part of the foot. Indeed, a reference to fig. 8 shows that the organ in question is rather a *hand* than a *foot*, and hence the term *quadrumanous* as applied to this class of animals. There is scarcely any plantar arch, and the weight of the body bears chiefly on the outer edge of the foot; the digits are long and strong, and the inner one diverges so as to form a thumb rather than a great toe.

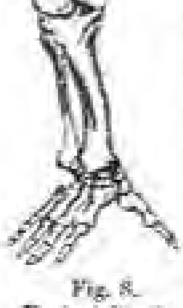


Fig. 8.
Foot of Gorilla.

It remains to notice some of the most marked varieties of form which the bones of the foot present in mammals. In the following group of figures the same letters are attached to the same bones. Thus, *a* marks the astragalus; *cl*, the calcaneum or heel-bone (the posterior projection of which forms the hock of the horse); *s*, the scaphoid; *b*, the cuboid; *ce*, the ecto- or outer, *cm*, the meso- or middle, *ci*, the ento- or internal cuneiform. Now, as a general rule in all mammalia, the ecto-cuneiform supports the third or middle of the five toes when they are all present, the meso-cuneiform the second, and the cuboid the fourth and fifth. Bearing in mind this law, we see that the large bone in the horse, known as the cannon-bone, which is articulated to the ecto-cuneiform, *ce*, is the metatarsal of the third toe, to which are articulated the three phalanges of that toe, the last phalanx, 3, being expanded to form the hoof. The small bone popularly known as the splint-bone (not shown in the figure), and articulated to the meso-cuneiform, is the rudimentary or stunted metatarsal of the second toe, 2; and the outer splint-bone, articulated to the cuboid, is the rudimentary metatarsal of the fourth toe, 4; so that in the horse we have only one toe, the third, sufficiently developed to reach the ground, with mere traces of a second and fourth toe on either side. In the foot of the ox the cuboid, *b*, is relatively larger than in the horse, and is equal in size to the ecto-cuneiform, *ce*. The cannon-bone articulates with both these tarsal bones, and hence answers to the metatarsal bones of both the *third* and *fourth* digits; it is accordingly found to consist of two distinct bones in the fœtus; and in the adult it is divided internally into two cavities, and its original separation is marked out by an external elongated ridge.

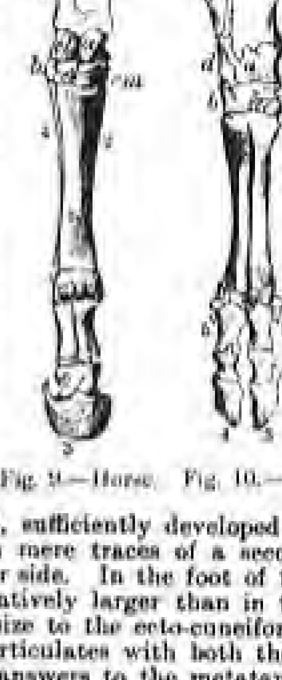


Fig. 9.—Horse. Fig. 10.—Ox.

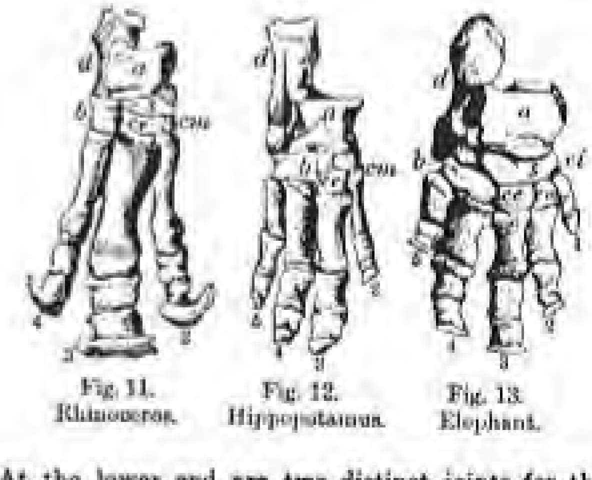


Fig. 11.
Rhinoceros.

Fig. 12.
Hippopotamus.

Fig. 13.
Elephant.

At the lower end are two distinct joints for the phalanges of the third and fourth toes. While in the horse we had the rudiments of the *upper* parts of two toes (the second and fourth), in the ox we have the rudiments of the *lower* parts or phalanges of two toes (the second and fifth), forming the 'spurious hoofs,' and marked 2 and 5 in the figure. In the rhinoceros there is one principal toe (the third), as in the horse, with the second and fourth toes in a less developed state; while in the hippopotamus there are two principal toes (the third and fourth), as in the ox, with the second and fifth toes not fully developed. In the elephant there is a fifth digit added, answering to our great toe, and articulating with an ento-cuneiform bone, so that in the foot of this animal we have all the bones occurring in the human foot. Owen concludes from these and similar observations that the course of the simplification of the five-toed foot is, first, a diminution and removal of the innermost toe; next, of the outermost; then, of the second; and lastly, of the fourth; the third or middle toe being the most constant and (in the lower animals) the most important of the five.

Foraminifera, a class of unicellular animals or Protozoa, almost always marine in distribution, most characteristically provided with limy shells, which have formed the chalk of the past and are now forming similar deposits in the deep sea. A living Foraminifer, often about the size of a pin's head, consists of a central nucleated mass of protoplasm, of a shell surrounding this, and of long, branched, and interlacing threads of living matter streaming outwards, with food-absorbing and locomotor functions.

Description.—The shell, which is much better known than its tenant, is characteristically calcareous, chambered, and covered with minute holes. But it is occasionally chitinoid, and often sandy, while a few forms approach Radiolarians in being flinty. At first a simple enough insheathing test, and so remaining in many forms, the shell is very generally added to, so as to cover successive overflowings of growth. The ways in which fresh chambers are formed—in linear series, in spirals, and the like—produce types of architecture of great beauty and variety, as to the building of which we can only conceal our ignorance by calling them organic crystallisations. The spirals often look like miniature sketches of the shells of Nautili, snails, and other molluscs. When partitions are formed between successive chambers they leave apertures through which bridges of protoplasm preserve the vital continuity. On the

Shells of various Foraminifera.

outer surface the outflowing protoplasm may reserve for itself one relatively large aperture, or a couple, or a few, but most characteristically there are numerous minute holes left all over the shell.

The internal protoplasm, so far as observed, is homogeneous, except for granules, frequent pigment, and the essential nucleus or nuclei. On the outflowing processes, which are more irregular and interlaced than is usual in Radiolarians, granules stream outwards and inwards in active currents. The colouring matter often resembles that of the diatoms on which the organisms so largely feed. The general absence of vacuoles, contractile or otherwise, is another of the contrasts between Foraminifera and Radiolarians, and is probably associated with the non-pelagic life of the former. Partner plant-cells or symbiotic algæ have been but rarely seen within Foraminifera, whereas they are almost constant in Radiolarians. Multiplication typically takes place by a sort of internal budding. The nucleus divides into several, round each product of nuclear division the protoplasm gathers, and thus are formed young individuals which are eventually enclosed in shells and liberated from the parent. Division of the entire animal has also been observed in a few cases. Dimorphism, or the occurrence of two diverse forms (possibly male and female) in one species, has been noticed, but no conjugation or incipient sexual union. In a few cases—e.g. *Microgromia socialis*—a number of individuals are united to form a loose colony, a primitive kind of association exhibited by not a few Protozoa. Most modern forms are small, below half an inch in diameter, and many very much less, down to microscopic dimensions. The largest living species (*Cyclo-clypeus carpenteri*) measures slightly over 2 inches across the shell, and recalls the extinct giant Nummulites, many of which were as large as half-crowns.

Distribution.—The Foraminifera are mostly marine, and occur at all depths; a few (Globigerinids), like the Radiolarians, are pelagic; most live on submerged objects or at the bottom. A few from brackish and even fresh water are known, and one species (*Gromia terricola*) has gone ashore. The pelagic forms as they die sink gently to the bottom, and are there forming, especially at depths between 1000 and 2000 fathoms, great beds of Globigerina ooze or modern chalk. In other regions sandy-shelled forms predominate at the bottom.

In marine geological strata from the Silurian onwards Foraminifera abound. Chalk consists almost wholly of fossil Globigerinids, and the Nummulites have contributed largely to the great Eocene limestones. The animal nature of Eozoon (q.v.) from the pre-Cambrian strata is now generally denied, and is at least very doubtful.

Position and Classification.—The Foraminifera were so named by D'Orbigny in 1826, and placed beside the Cephalopods, to the shells of some of which the tests present a mimetic or prophetic resemblance. The title referred not, as might be supposed, to the superficial apertures on the shell, but to the communications between successive chambers. Hertwig would call them Thalamophora, in allusion to the typical chambered shell; while Carpenter emphasised the living network of processes in the title Reticularia. Accenting as they do the amœboid phase of cell-life, the Foraminifera have their place beside Amœbæ, Radiolarians, and Sun-animalcules in the Rhizopod division of Protozoa (q.v.). They were formerly classified as Perforate and Imperforate according to the presence or absence of numerous apertures on the test, but as this distinction separates apparently adjacent forms it is no longer generally adopted. By Brady, who has described the *Challenger* collection in a monumental monograph, they are classified in ten families, of which Gromia, Miliolina, Astrorhiza, Lituolina, Textularia, Chilostomella, Lagena, Globigerina, Rotalia, and Nummulites are the name-giving types. In Gromia the shell is chitinoid, flexible, and with a single aperture; in the related Shepheardella there is an aperture at each end of an elongated test. The test of Miliolina is normally of lime, but in brackish water tends to become chitinoid, and at great depths a siliceous film. Irregular sand particles form the primitive test of Astrorhiza, and the use of detached sponge spicules led to the related Haliphysema being mistaken for a very simple sponge. Among Lituolidæ, Parkeria and Loftusia are relatively large forms—about two inches in diameter and length respectively. A peculiarly interesting *Challenger* form among the pelagic Globigerinids—*Hastigerina murrayi*—has the shell surrounded by a zone of bubbly protoplasm, and in its vacuoles and internal shell suggests Radiolarian characteristics. The species of Foraminifera are legion, probably above two thousand. They are interesting, as illustrating complexity and beauty of architecture at the very threshold of life, and important both in the making of the earth and in the present-day economy of submarine life.

See EOZOON, NUMMULITES, OOZE, PROTOZOA, RADIOLARIANS.

Formic Acid, CH_2O_2 or $HCOOH$, derives its name from the circumstance of its having been first obtained from the red ant (*Formica rufa*). It occurs in ants, in the stings of bees, wasps, and nettles, in fir needles, and in various animal secretions. It may be obtained from any of these by distillation with water. Anhydrous formic acid is a mobile liquid of extremely penetrating odour, crystallising at 35° F., and boiling at 214° F., miscible in all proportions with water and alcohol. It produces a painful blister if dropped on the skin. The aqueous acid is prepared in the following manner: Half a pound of oxalic acid is mixed with one pound of glycerine, and the mixture heated in a retort to 275° F.; a little dilute formic acid distils; another quantity of oxalic acid is added, and the mixture again heated, and so on indefinitely, the glycerine remaining unchanged at the end of the operation. The decomposition is as follows:

$$\underset{\text{Oxalic Acid.}}{C_2H_2O_4} \;=\; \underset{\text{Formic Acid.}}{CO_2H_2} \;+\; \underset{\text{Carbonic Acid.}}{CO_2}$$

Acid containing 56 per cent. of the pure substance is obtained in this way. The anhydrous acid is procured by preparing the lead salt, and decomposing this with sulphuretted hydrogen. It may be formed synthetically in various ways: (1) By direct combination of carbonic oxide, CO, and caustic potash, KOH, forming KCO_2H, potassium formate; (2) by boiling aqueous prussic acid; (3) by heating chloroform with caustic potash. Formic acid and all its salts (called formates or formiates) are strong reducing agents, and precipitate metal from solutions of gold, silver, or mercury salts. Formic acid is obtained in small quantities by the oxidation of a great number of organic substances. Formates of silver and lead are sparingly soluble; all the others are freely so. By heat they are converted into oxalates yielding pure hydrogen.

$$\underset{\text{Potassium Formate.}}{2KCO_2H} \;=\; \underset{\text{Potassium Oxalate.}}{K_2C_2O_4} \;+\; \underset{\text{Hydrogen.}}{H_2}$$

Foxglove, a species of Digitalis (q.v.). The Common Foxglove (*D. purpurea*) is a native of Britain, and a familiar and conspicuous ornament in woods and hedgerows, its flowering stem reaching a height of from 2 to 4 feet, or even more. It flowers from June to August. Both it and its white-flowered variety are frequently planted in gardens and shrubberies. Its English name, the German name Fingerhut ('thimble'), and the botanical name Digitalis (Lat. *digitale*, 'the finger of a glove') refer to the form of its flowers. The foxglove was a favourite with the fairies, and was called in Ireland Fairy-cap, and in Wales Elf-glove, elsewhere Fairy-fingers, Fairy-petticoats. But there seems no good ground for the attempt to make out that foxglove is a corruption of Folk's-glove, for Good-folk's Glove, or Fairy-glove. Another English provincial name is Fox-fingers.

Common Foxglove (*Digitalis purpurea*).

Frankincense (Lat. *thus*), a name employed to designate various fragrant resinous substances which diffuse a strong fragrance in burning, and are on that account used in certain religious services. The frankincense of the Jews, and also of the ancient Greeks and Romans, was chiefly or entirely the substance now known as *Olibanum* (q.v.), the produce of an Amyridaceous Indian tree (see BOSWELLIA). Several trees, however, of different orders, yield substances used as frankincense instead of olibanum, in different parts of the world, as several species of Icica and of Croton in America; and the common fir (see FIR) in Europe, the resinous product of which is the Common Frankincense of the pharmacopœias, although in the shops concrete American turpentine is very often sold under this name. It is used in the composition of stimulating plasters, &c. Burgundy pitch is made from it. It is a spontaneous exudation from the tree, hardening by exposure to the air, and generally of a whitish or pinkish colour, with a rather agreeable odour and a balsamic taste. See INCENSE.

Freezing Mixtures. When matter passes from the solid to the liquid, or from the liquid to the gaseous (or vaporous) state, a considerable quantity of heat in general disappears or is rendered 'latent,' owing to the fact that, energy being required to effect these changes of molecular state, it is taken from the energy in the form of heat already existing in the substance; and this abstraction of heat causes a fall of temperature (see HEAT; MATTER, STATES OF). This property is taken advantage of for the production of low temperatures. The solution of a salt in a liquid, and the liquefaction of two or more solid substances when mixed, are both examples of the change from the solid to the liquid state, accompanied by a lowering of temperature, unless this be neutralised by heat developed by some purely chemical action. The following table gives the composition of freezing mixtures commonly in use. The solid materials should be finely powdered and intimately mixed together in a vessel of low thermal conductivity. The first column of the table gives the components in each mixture; the second their relative proportions by weight; in the third the resulting temperature (Centigrade) of the mixture, assuming that, with the exception of snow or ice, the temperature of the materials previous to mixture is 10° C. The fourth column gives the diminution of temperature in degrees Centigrade:

Components.	Relative proportion by weight.	Temperature of mixture.	Diminution of temperature.
Water	1	16°	26°
Ammonium nitrate	1		
Snow or pounded ice	5	...	20°
Common salt	2		
Snow or pounded ice	1	...	45°
Calcium chloride, crystals	2		
Ammonium nitrate	1		
Sodium carbonate	1	14°	24°
Water	1		
Sodium phosphate	27		
Ammonium nitrate	18	29°	39°
Fuming nitrous acid	8		
Water	4		
Sodium sulphate	8	16°	26°
Hydrochloric acid	5		
Snow	8	32°	42°
Hydrochloric acid (at 0° C.)	5		

Such mixtures are only applicable where a low temperature is required for a short space of time, and are of no use where a continuous process of refrigeration is necessary. For this latter purpose the low temperature produced by the expansion of gases and vapours is chiefly used, the principal substances employed being water, ether, ammonia, and carbon bisulphite. A full account of these processes, and of the apparatus connected with them, will be found under REFRIGERATION. Low temperatures are also obtained by the evaporation of a liquid, either under artificially diminished pressure, or where its vapour pressure is constantly small; the energy necessary to effect the change of state being taken from the heat in the substance itself. The evaporation (and consequent cooling) of water from the surface of porous earthenware vessels, called water-coolers, is due to this principle. The same is true of the formation of ice in shallow lakes at night in tropical climates.

The extremely low temperatures reached by Natterer and others, in their experiments on the liquefaction of gas, were obtained by a mixture of solid carbonic anhydride and ether; or of solid nitrous oxide and carbon bisulphide. By such means the temperature of $-140°$ C., the lowest yet attained, was reached. See also COLD, FROST, ICE, THERMOMETER, WATER.

French Polishing, the name given to the usual method of polishing furniture. Simple varnishing with copal or mastic varnish, put on with a brush, produces a comparatively uneven surface, which soon wears off with friction. A French-polished surface, on the other hand, is beautifully smooth, glossy, and very durable if occasionally rubbed over with ordinary furniture paste. The process consists in rubbing the 'polish,' which chiefly consists of shell-lac dissolved in alcohol (methylated spirit), well into the pores of the wood. After it has been left for a night to harden, the surface is next rubbed over with sand-paper. These operations are repeated several times, but the wood finally receives two rubbings with the polish only. The pads or rubbers used are either of flannel or cotton-wool, covered with thin calico dipped in linseed-oil. An 'egg shell' finish is given to the surface either by rubbing over the ordinary French-polished surface with pumice and linseed-oil, or by applying the polishing solution in a thin state. Ebony, satinwood, and Spanish mahogany are more easily polished than oak, American walnut, or rosewood. Neither vessels containing hot water nor bottles of perfumes made up with alcohol should be placed on polished wood.

The composition of French polish, sometimes called cabinetmakers' polish, varies very much. A good receipt is 1½ lb. shell-lac, 1 oz. mastic, 2 oz. gum benzoin, 1 gallon methylated spirit. Another is 10 parts shell-lac, 40 parts methylated spirit. For light-coloured woods the polish should be made of white shell-lac.

Fulminates. This term is applied to a class of salts having the same percentage composition as the cyanates (see CYANOGEN), but, unlike them, exploding violently when heated or struck. Like Gun-cotton (q.v.) and Dynamite (q.v.) these salts contain the group of atoms represented by the formula NO_2, and which seems to confer explosive properties in so many cases. There are many fulminates corresponding to the different metals, but it will suffice if attention is drawn to fulminating mercury and silver. *Fulminating mercury* is prepared by heating mercury with alcohol and nitric acid, and after purification it is obtained in white silky crystals, which have a sweetish taste and are soluble in water. When moist these crystals may be handled without risk of explosion, but when dry they detonate violently on being struck or when a spark falls on them. This salt is largely used in the manufacture of percussion caps, for which purpose it is mixed with nitre, sulphur, &c. *Fulminating silver* is prepared by heating a solution of nitrate of silver with nitric acid and alcohol. It forms small white needles having a bitter taste and poisonous properties. It explodes more readily than the mercury salt, and the greatest care is requisite in its manufacture. It is used in making crackers and other detonating toys.

The fulminates should never be prepared by amateurs, as accidents very readily occur.

Fumaric Acid,
$H_2C_4H_2O_4$, occurs in many plants, especially in Corydalis and Fumitory. It is of interest from a chemical point of view as being isomeric with malic acid.

Fungi. The early botanists 'considered the fungi to be *lusus naturæ* and no plants at all,' and regarded their strange and fitful appearance without flower or apparent seed as the strongest argument for spontaneous generation. The bland wholesomeness of some, yet frightful poisonousness or destructiveness of many others, with their consequent world-old association with that crude and fanciful pharmacy in which ancient medicine and witchcraft were so inseparably intermingled, not a little enhanced these mysteries. Hence, although in Sterbeeck's *Theatrum Fungorum* (1675), the first published book entirely devoted to cryptogamic plants, there is an excellent account and many figures of fungi, it was not, and indeed could not be, until after that primary task of natural science initiated by Linnæus—the compilation of the 'System of Nature,' the orderly descriptive catalogue of natural things—had made considerable progress in almost all other directions, that its chapter dealing with the fungi was fully commenced. From about 1780 onwards we have illustrated cryptogamic floras essentially of the modern type, which not only soon reached tolerable completeness for the more obvious forms, but with the introduction and improvement of the microscope even made rapid progress with that description of the multifarious minor forms which is even now far from ended. It thus became known that some were produced from reproductive cells or spores, just like a plant from its seed; hence for this Linnean school, whose central monument is the works of Fries, each new form was, naturally enough, simply a new species to be described. The identification, however, of the fern and its prothallus (see FERNS) as phases of a single life-history, and the thorough reinterpretation of the higher cryptogams and their unification with the flowering plants thereupon effected by Hofmeister, naturally gave a fresh impetus to the study of the remaining lower groups of algæ and fungi. For fungi, this new movement was headed by Tulasne, who from 1851 onwards showed that many of the different form-species hitherto described were actually nothing more than the phases of a single protean life-history. Tulasne essentially relied upon the actual anatomical continuity of different adult forms, upon finding reproductive structures hitherto regarded as specifically distinct on one and the same vegetative body or mycelium; while De Bary confirmed and extended these results by the complementary method of cultivation from the spore. Tulasne's new doctrine of 'the pleomorphism of the fungi' aroused storms of controversy; but the bigoted conservatism of the systematists in the defence of their results, and the exaggerated speculation and practical blundering of the younger school in the reinterpretation of them, gradually subsided as the just claims of each obtained mutual recognition; and thanks to many workers, but especially to the exact labours of De Bary and his many pupils, the classification and morphology of fungi have thereafter been in harmonious progress.

It was long before any satisfactory definition of fungi was possible, their association with algæ (themselves scarcely better known) at first resting merely upon the negative characters which excluded both from the higher plants. Their physiological peculiarities, however, were more apparent; and their definition as a 'natural order' (or, as it gradually appeared, a vast class) was accepted as 'embracing all Thallophytes which do not vegetate by means of intrinsic chlorophyll.' The progress of research demonstrated the remote distinctness of some types of these from others, and the intimate relationship of certain fungi to particular algæ of which they seemed to be merely the colourless forms. Hence it was argued, especially by the physiologist Sachs, that such forms were no more entitled to separate classification apart from the algæ than were the very various types of flowering plants—e.g. dodder and broom-rape—which merely agree in having lost their chlorophyll through parasitism, apart from the ordinary green plants to which they are respectively akin. Abandoning, then, the physiology of the vegetative system, he proposed a classification of the algæ and fungi according to their degree of reproductive development (see ALGÆ). This was, however, going too far, and systematists have returned to the more conservative proposals of De Bary, who excludes entirely from the fungi the Bacteria (q.v.) and the Myxomycetes, and, while recognising that certain fungi are doubtless merely the colourless representatives of particular algal groups, yet vastly simplifies the subject by insisting upon 'an Ascomycetous series or main series of fungi,' albeit with more or less doubtfully related outlying forms.

At the outset of this great series are usually described two orders (sometimes united as Oomycetes); both closely related in vegetative and reproductive type to such simple algæ as Vaucheria (see ALGÆ). These are the Peronosporeæ, including such well-known moulds of living plants as *Phytophthora infestans* (Potato Disease, q.v.), *Cystopus candidus* (White Rust of cruciferous plants), also Pythium and Peronospora. The allied Saprolegnia (see SALMON) gives its name to the other family.

Of the Zygomycetes the commonest type is *Mucor mucedo*, the common white mould of dead

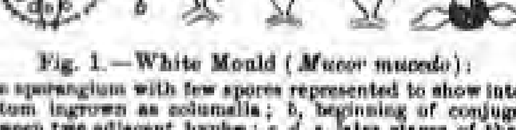


Fig. 1.—White Mould (*Mucor mucedo*):
a, ripe sporangium with few spores represented to show internal septum ingrown as columella; b, beginning of conjugation between two adjacent hyphæ; c, d, e, later stages of the process; f, germination of the thick-walled resting spore, with short vegetative and immediate reproductive hypha.

organic matter, particularly horse-dung, a form easily cultivated and in every way peculiarly suitable for beginning the study of fungology. Starting with a spore, this germinates into a filament or *hypha*, which remains unicellular like that of the preceding forms, and grows and branches rapidly through the nutrient material or solution, the whole growth of hyphæ being termed the *mycelium*. Soon erect hyphæ begin to bud from the older hyphæ of the mycelium; the tips of these enlarge into spherical heads, which become separated off as distinct cells, the future sporangium, by a partition which grows, however, inwards, into the interior of the enlarging spherical head, as the *columella*. The protoplasm of the sporangium is meantime dividing into a multitude of tiny cells, which surround themselves with cell-walls as spores, while the mineral waste products of this active change are deposited in the common sporangial wall, rendering it exceedingly brittle. This readily breaks, scattering the spores, which immediately recommence the same development.

Sooner or later, however, a more evolved process of reproduction is needed, and two adjacent hyphæ conjugate much as in Spirogyra (see fig. 1, b—e, and ALGÆ, fig. 4). The resultant zygospore after a period of rest germinates with only a rudimentary mycelium, and immediately reproduces the characteristic asexual sporangium. Empusa, of which *E. muscæ* is largely fatal to house-flies in autumn, is the type of the analogous order Entomophthoreæ. The Chytridiaceæ are an order of minute fungi of which the life-history is fundamentally similar to that of the Protococcaceæ among algæ.

The Ustilagineæ are a large family, parasitic on phanerogamous plants. Their mycelium ramifies through the intercellular spaces of the host, and

forms also densely-woven masses of spore-bearing hyphæ, which show various degrees of differentiation as *compound sporophores*, so foreshadowing those of higher fungi. These spores produce a short mycelium, of which the branches conjugate in pairs, while the new mycelia thereafter arising re-enter the plant and in time produce new asexual spores. Some are formidable pests of agriculture (Ustilago, Tilletia).

ASCOMYCETES proper.—The mycelium is always composed of multicellular hyphæ, which in the higher forms interweave into the stroma or thallus, which assumes various characteristic forms and bears the short reproductive hyphæ, which in turn bear the spore-mother cells or *asci*. These are usually tubular, and on reaching full size their protoplasm collects at the top, and the nucleus

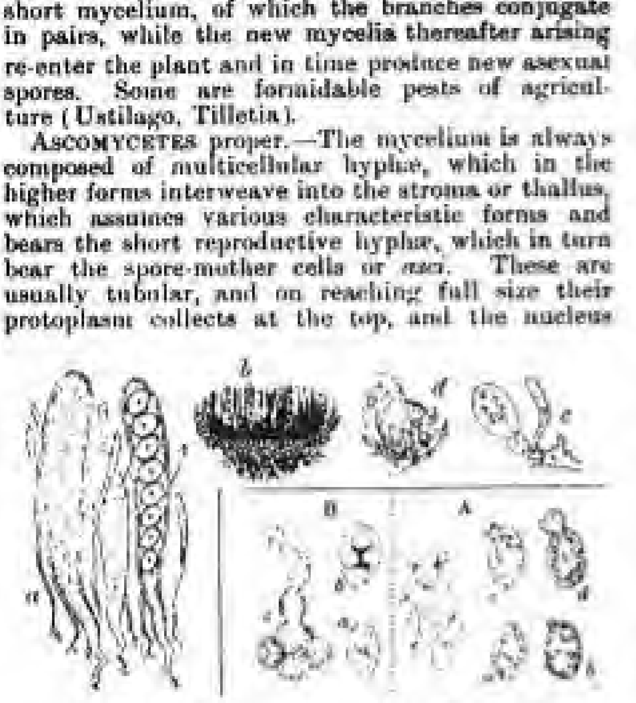


Fig. 2.—Peziza.
a, asci, with barren filaments (paraphyses); b, section of fructification surface (hymenium); c, preparations for the sexual process which precedes the development of the fungus-body; d, fertilisation, with upgrowth of an enveloping tissue, the incipient sporocarp.

Fig. 2a.—Yeast (*Saccharomyces cerevisiæ*):
A, a, b, c, d, early stages of budding; e, later stages; B, starved yeast cell, dividing at a to form four ascospores at b; c, subsequent germination on return to nutritive fluid.

divides repeatedly, usually producing eight nuclei, which collect protoplasm around them, and, developing cell-walls, become perfect *ascospores*. In all save a few of the lowest forms (Eremascus, Exoascus, &c., which are accordingly grouped as Gymnoasci) the fructification is in distinctly developed *sporocarps*. In these, besides the ascogenous hyphæ with their asci, there is an *envelope* derived from distinct hyphæ of the stroma, which also send in amongst the asci a multitude of barren filaments, the *paraphyses*. The aggregate of asci and paraphyses is termed the hymenium (see fig. 2, a, b). Tulasne and De Bary have shown with tolerable certainty (despite the doubts of Van Tieghem and Brefeld) that the whole fructification arises in consequence of a conjugation of similar hyphæ in the lowest forms (Eremascus), or the sexual union of dissimilar ones in higher forms (e.g. Peziza, fig. 2, c, d).

A brief systematic enumeration of the orders and leading illustrative forms of Ascomycetes will be found of service:

(1) *Gymnoasci*.—Asci not forming definite sporocarps with envelope (Eremascus, Exoascus).

(2) *Discomycetes* (800 species).—Sporocarp with envelope, but hymenium completely uncovered, at least at maturity. The most important genus is Peziza, of which the shallow cup-like sporocarp is open from the beginning, though in the allied Ascobolus the envelope encloses the hymenium during development and bursts, scattering the spores. Bulgaria resembles this, but is gelatinous. In Dermatia the cup is leathery or horny. In Stictis the hymenium is almost withdrawn into the stroma, while in Phacidium the sporocarp only breaks out and opens when ripe. In a second but less important family the sporocarps are leathery and black, elliptical, linear, or winding; of these Hysteriæ the commonest is *Rhytisma acerinum*, which forms the large black spots that appear upon almost every leaf of the common maple towards autumn. The Helvellacei represent an opposite type of development; the large sporocarps are stalked, with club or hat shaped hymenia, open and uncovered by the envelope from the beginning. Many are important as esculent, notably the morels (*Morchella esculenta*, *deliciosa*, &c.), also *Helvella esculenta*. The mycelium of *Rœsleria hypogæa*, found on dead and diseased vine-roots, is the 'pourridié de la vigne' of wine-growers.

Among the Discomycetes the life-history is often rendered more complex by the mycelium constricting off *acrospores* from the tips of erect filaments, these acrospores readily reproducing the mycelium. This stage of *Peziza Fuckeliana* was formerly known as *Botrytis cinerea*; and many other acrospore-bearing moulds still await similar identification. Vegetative hyphæ also frequently interweave into dense resting masses or *sclerotia*, as also in the species just named, and these may either redevelop acrospore-bearing hyphæ or (after a winter) give rise to true hymenial cups. Acrospores, too, may be developed either upon isolated hyphæ or in pseudo-hymenial groups, which may be open or flask-shaped (*pycnidia*). Nor are the many possibilities of 'pleomorphic' variation thus opened up by any means confined to the Discomycetes.

(3) *Pyrenomycetes*.—This is a large order of small and inconspicuous fungi, in all respects representing a further differentiation of the Discomycete type, primarily in the deepening of the shallow cup-shaped hymenium into a deep flask with minute apical opening (*perithecium*), but also in a more varied development—the most extreme among fungi—of pleomorphism or alternation of generations. The number of species is hence very uncertain. Besides the important Ergot (*Claviceps purpurea*, see ERGOT), and its curious ally Cordyceps, which attacks caterpillars, moths, wasps, &c., with its fructification, thus forming the extraordinary 'animal-plants' and 'vegetating insects' which so perplexed the early naturalists, any of the common forms into which the old (and once all-comprehensive) genus Sphæria has been broken up will serve as type, conveniently Nectria, common in red patches upon dead wood. Some form parasitic patches within lichens.

(4) *Perisporiaceæ*.—In these the perithecia are completely closed capsules which fall to pieces on ripening; there are no paraphyses. The mycelium is thread-like, and acrospores are frequent. Of the 100 species some are notable pests, witness Erysiphe and others, commonly grouped as Mildew (q.v.), *Oidium Tuckeri*, a pestilent vine disease, &c. Easily distinguished by the dark or inconspicuous mycelium are the species of Fumago. To this group also belongs Eurotium, of which the common Bread Mould (*E. Aspergillus-glaucus*) is a type commonly put before the botanical student, from the comparative facility with which the sexual

process, which sets in after prolonged multiplication by acrospores, can be observed, with its resultant

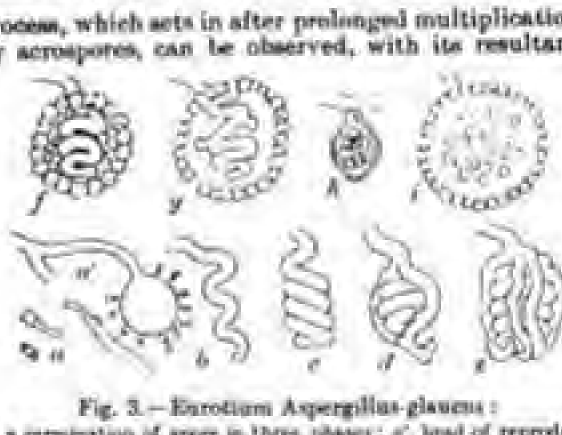


Fig. 3.—Eurotium Aspergillus-glaucus:
a, a germination of spore in three phases; a′, head of reproductive hyphæ bearing spores; b, c, appearance of conjugating filaments; d, e, growth of enveloping coat, complete in f; g, first appearance of asci (two buds); h, a ripe ascus; i, spores lying loose and ready to be set free.

development of the perithecium and its asci (see fig. 3).

(5) *Tuberaceæ*.—In this group, as in the preceding, the hymenium is permanently without external opening, but the chambers become narrow, coiled, and branched, and the whole complex sporocarp thus attains an extreme complexity. Most are subterranean, and are best represented by the important genus Tuber (see TRUFFLE). With this (or sometimes in the last group near Elaphomyces) is to be reckoned the very common mould of jam, bread, &c. (*Penicillium glaucum*); it rarely, however, attains full development beyond the acrospore-bearing form.

(6) *Lichenes*.—As the majority of lichen-forming fungi belong to the Ascomycetes, the lichens are very commonly now described under this head by recent writers. Yet not only the time-honoured distinctness of this group, but its remarkable variety and interest make separate treatment still expedient, hence see LICHENS.

Besides the large number of forms in which the existence of an acrosporous phase as yet rests upon analogy alone, De Bary reckons as 'doubtful Ascomycetes' such forms as Laboulbenia, Exoascus, and also the important species which excite alcoholic fermentations, Saccharomyces (fig. 2a). See YEAST, FERMENTATION.

From forms in which the characteristic mode of reproduction of the Ascomycetes is only doubtfully represented we readily pass to those in which it does not appear at all, but in which multiplication occurs only by acrospores or basidiospores, which may be of various forms. One group, however, we have to consider in which the sporocarp, here termed an *æcidium*, so closely resembles that of an Ascomycete as to induce De Bary and most writers to reckon it with these rather than with the following series.

(7) *The Uredineæ or Æcidiomycetes*.—These are the Rust fungi, a remarkable series of parasitic moulds, formerly associated with the Ustilagineæ, which they somewhat resemble in habit, but from which they differ in structure and life-history. The alternation of generations is remarkably complete and well differentiated, the different forms having constantly been reckoned in distinct genera, which are as yet by no means fully criticised. The most familiar case is that of the Rust of wheat (*Puccinia graminis*), in which the generation found on the barberry was described as *Æcidium berberidis*. Other important forms are known as *Uredo* sp. &c.; to this group is also reckoned the coffee disease of Ceylon, *Hemileia vastatrix*. The life-history of the group will be understood by reference to RUST.

BASIDIOMYCETES.—We now come to the Basidiomycetes proper, which derive their name from the *basidia* which segment off or 'abjoint' the spores (fig. 4, d). These are usually non-parasitic and have generally large and well-developed sporocarps; they are divided into two main groups.

A. HYMENOMYCETES.—Hymenium exposed upon the surface of the sporocarp.

(*a*) *Tremellini*.—Gelatinous with basidia each bearing only one spore, often arising laterally—Auricularia (Jew's Ear), Tremella (q.v.).

(*b*) *Hymenomycetes proper*, not gelatinous, two to six spores arising on each basidium (fig. 4, a—d).

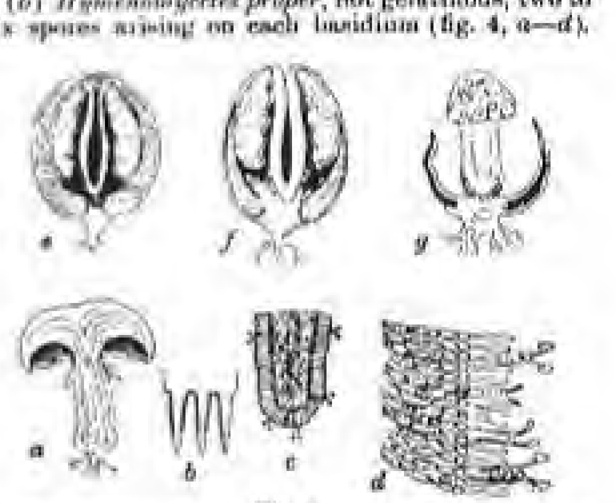


Fig. 4.
a, vertical section of an agaric (*Hymenomycetes*); b, section of three 'gills;' c, section of tip of gill, showing course of hyphæ-bearing basidia, of which five bear spores; d, portion more highly magnified; e, young Phallus (*Gasteromycetes*); f, the same at moment of rupture of peridium; g, more fully opened (the same figure on a smaller scale).

In the simplest forms the sporocarp is erect or branched, and bears a hymenium over its whole surface. Of this small group of (1) Clavarinei many species of Clavaria are common.

(2) In the allied Thelephorei the hymenium forms also a simple smooth surface, but is restricted either to the upper or under surface; in the latter case the fungus may be sessile or stalked, and have a distinct 'hat' or pileus (Thelephora, Stereum, &c.).

(3) In the Hydnei the hymenium becomes differentiated in various irregular and discontinuous forms, which may be warty, bristly, or comb-like.

(4) In the Polyporei the hymenium is continuous, but with many more or less tubular depressions. Here belong several important genera, notably Boletus (q.v.), Polyporus (see AMADOU), Fistulina (q.v.), as well as the pestilent *Merulius lachrymans* (Dry Rot, q.v.).

(5) In the immense group of Agaricini (1200 European species) the series culminates, the hymenium being arranged in regular radiating lamellæ or gills. Most important of course is the genus Agaricus and Mushroom (q.v.), which is broken up into many subgenera (Amanita, Armillaria, &c.). Cortinarius, Hygrophorus, Russula, Lactarius, Coprinus, Cantharellus (chantrelle), Marasmius are also important. Many of these are edible, others again poisonous.

B. GASTEROMYCETES.—Here the spores arise quite as in Basidiomycetes; but the hymenia are completely enclosed within the fungus-body. Of this the outer layer (*peridium*) becomes differentiated from the deeper substance (*gleba*). Both layers may undergo very remarkable histological and anatomical modifications, and these changes of ripening often result in the sudden acquirement of the most extraordinary forms. Hence, although the species are by no means so numerous (about 550), there are 70 genera. These are mostly large fungi, often edible, at least in the young state; few are positively poisonous.

(1) Of the mostly subterranean and truffle-like Hymenogastrei, one genus, Gautiera, affords an interesting transition from the Hymenomycetes, its hymenial depressions remaining open and uncovered by any differentiated peridium. In the remaining types (Hymenogaster, &c.) the gleba contains many closed internal hymenial chambers, but remains continuous with the simple peridial coat.

(2) The Sclerodermei differ little from the preceding, save in the more differentiated peridium, from which the gleba dries away in a brittle network, lining the chambers, which become filled with spores. *Scleroderma vulgare* is sometimes used as an adulterant of truffles, but is commonly regarded as inedible.

(3) In the simplest Lycoperdinei or puff-balls the gleba may remain unchambered, but the tissue of the gleba usually breaks up into a woolly mass of dried hyphæ; hence the peridium when broken on ripening discloses a dusty mass of threads and spores (Lycoperdon, Bovista). See PUFF-BALL.

(4) In another series, the Phalloidei in the widest sense, we have a very singular series of forms. This begins with the simple earth-star (Geaster), which is essentially a puff-ball with outer and inner peridium, of which the outer opens into radiating lobes. In Batarrea, the gleba, covered with the inner peridium, becomes raised upon a long stalk; in Phallus (see fig. 4, *e, f, g*) the outer peridium, fibrous outside, becomes gelatinous within, while the stalk pushes the gleba through the inner peridium also, as a naked cap from which the spores drop away; while in Clathrus it is the inner peridium which expands as a large network.

(5) In the last series, that of Nidulariei, the external peridium opens, disclosing several separate 'peridioles,' each containing a hymenial tissue, which breaks down into a mass of spores. These are the 'bird's-nest fungi' (Cyathus, Nidularia, &c.). The origin of the Gasteromycete sporocarp from its mycelium appears to be without any sexual process, but by a process of direct growth and differentiation of an upgrowth upon its mycelium. In Hymenomycetes a sexual process has been sometimes described, but not with absolute certainty. We know, however, how constantly the abundant nutrition of an organism leads to the relapse from sexual to asexual multiplication.

As an appendix to this outline of classification, it is necessary to note that we not unfrequently find sterile mycelium forms, to which any definite systematic position frequently cannot be given. Such are, for instance, the well-known *Racodium cellare* of wine-cellars. There has been much dispute over the nature of the complex strands of Rhizomorpha, now regarded as belonging for the most part to *Agaricus melleus*, while the old genus Sclerotium has long been recognised as a resting state of many diverse forms—e.g. Ergot.

Germination.—Most spores are capable of immediate germination: such are most acrospores (*gonidia*), almost all acrospores, and most spores of Hymenomycetes. Some, however, require a period of rest: such are most oospores, zygospores, winter spores, &c. Although some spores perish almost immediately, many others exhibit considerable powers of resistance to heat, cold, drought, &c.; those of some moulds have been germinated from herbarium specimens three to ten years old. For germination we require a reasonable temperature, varying with the species, with supply of oxygen and moisture; nutritive matter may also be necessary. Many spores, however, have never as yet been observed to germinate at all, notably those of the truffle and some other Ascomycetes, of most Gasteromycetes, and of a few Hymenomycetes, including even the common mushroom.

Nutrition and Mode of Life.—The characteristic absence of chlorophyll renders the fungus unable to decompose carbonic anhydride. Hence it must depend upon organic compounds already formed. Almost any soluble carbon compound, not too poisonous or too fully oxidised (such as formic or oxalic acid, urea, &c.), will, however, serve for this, and similarly with most nitrogen compounds, even urea. The constituents of the ash can also be obtained from a wide range of substances. Penicillium grows best in a solution of proteid (peptone) and sugar, yet can be grown, of course with diminishing vigour, upon a whole series of poorer solutions, down to ammonium acetate. All of course give off carbonic acid in respiration, and a few are remarkably phosphorescent.

Such facts help us more clearly to understand the wide range of habitat presented not only by the different members of the group, but by the same species. Those fungi which normally obtain their organic matter from the dead organic matter of decaying bodies are termed *saprophytes*, while those which obtain them from living plants or animals are termed *parasites*. The former is doubtless to be regarded as the primary state of things, and includes the great majority of fungi, yet many normal saprophytes exhibit 'facultative parasitism,' and conversely normal parasites may exhibit 'facultative saprophytism.' Many saprophytes require a specific substratum—e.g. dung, feathers, &c. —just as many parasites have only a single host; others again have a very wide range of habitat. The chemical effects of the growth of fungi, with which, for physiological purposes, we may also reckon the Bacteria (q.v.), upon organic substances are outlined under FERMENTATION and PUTREFACTION. The relation of specific parasites to their hosts, besides mention in the various special articles, such as ERGOT, MILDEW, and RUST, is more generally treated under PLANTS (DISEASES OF) and PARASITISM; the pathological bearings come under GERM THEORY and PATHOLOGY. That remarkable adjustment of fungus and host which rises beyond the pathological level into the healthy and permanent mutual adaptation known as *symbiosis* is described, for the association of fungus and alga, under LICHENS, and for that of fungus-mycelia with the roots of phanerogamous trees, the so-called Mycorhiza, under ROOT.

Uses of Fungi.—Of species used in medicine, the only one now of importance is Ergot (q.v.); the narcotic use of the Siberian fungus has also been described under AMANITA. Amadou (q.v.) and MOXA (q.v.) are old sources of tinder, and *Polyporus squamosus*, cut in slices, was much used for razor-strops. But the chief use of fungi is for food, and in the manufacture of Ketchup (q.v.).

Although few fungi are used as food, and most popularly regarded as poisonous, the positively dangerous species are really by no means very numerous. Yet the risks of incautious gathering must not be understated, since not only are some edible fungi liable to be confounded with poisonous forms, but some normally wholesome forms acquire poisonous properties under particular circumstances, although whether this be due to definite variation or to the chemical changes of incipient decomposition remains doubtful. Hence our common mushroom is excluded from the Italian markets. There is no certain rule which can supersede the need of experience and caution in discriminating wholesome from unwholesome forms, the popular beliefs—e.g. that the latter only will discolour a silver spoon if stirred with it while being cooked, or that they are more readily deliquescent—being without foundation. Nor does colour or odour afford any certain test, for, although most forms of gaudy exterior or readily changeable internal colour may be suspected, and all fetid ones of course avoided, some poisonous ones are quite inconspicuous and inoffensive. Again, some which are pungent and acrid while raw become bland and wholesome when cooked; maceration in vinegar or brine produces a similar effect.

The importance of fungi as an article of diet is naturally minimised in Britain through the prevailing ignorance and the consequent excessive distrust; in France, and especially in Italy, they are of much greater importance. The culture of the Mushroom has, however, of late years become increasingly frequent, while on the Continent that of a number of other species has long been practised with more or less success, as notably of Agaricus, Boletus, &c., and more recently of the truffle. The leading edible fungi have already been noted, and are also in most cases the subject of separate articles; it may suffice therefore here to bring together the most important. Besides the Mushroom, its immediate congeners, and its closer allies, such as the Chantrelle (*Cantharellus cibarius*), we have among the Hymenomycetes a number of species of Boletus and of Polyporus, also *Fistulina hepatica*, and several species of Lactarius, Hydnum, and Clavaria, with *Marasmius oreades*. Among Gasteromycetes, the puff-balls (Lycoperdon, Bovista), in the young state. Of Ascomycetes, the Morel, Helvella, with Verpa, some of Peziza, &c., and, of course, above all others, the Truffle. *Cyttaria Darwinii*, which grows on beeches in Tierra del Fuego, forms an important article of native diet.

Poisonous Effects and Treatment.—Noxious species may produce sometimes irritant, sometimes narcotic effects. The effects appear soon after the meal, and may be manifested by giddiness, dimness of sight, and debility. The person may seem intoxicated, and there may be singular illusions of sense, while even spasms and convulsions may appear in the most serious cases. In most cases, however, recovery takes place, especially if vomiting be early induced. Hence emetics should be administered as promptly as possible, and castor-oil also given freely.

Furfuramide is closely related to FURFURINE and FURFUROL, and all three substances may be prepared from wood. When this is heated with water under pressure for some time, and the resulting liquor distilled, furfurol, $C_5H_4O_2$, an aromatic oil, with an odour resembling cinnamon and bitter almonds, is obtained. By treatment with ammonia this is converted into furfuramide, $C_{15}H_{12}N_2O_3$, a neutral crystalline body. By boiling this again with a solution of potash, furfurine, an alkaline base having the same composition as, and isomeric with, furfuramide is produced. These substances are of little industrial importance.

Fusel or **Fousel Oil,** known also as POTATO SPIRIT, is a frequent impurity in spirits distilled from fermented potatoes, barley, rye, &c., to which it communicates a peculiar and offensive odour and taste, and an unwholesome property. Being less volatile than either alcohol or water, it accumulates in the last portions of the distilled liquor. It is principally formed in the fermentation of alkaline or neutral liquids, but does not occur in acidulous fermenting fluids which contain tartaric, racemic, or citric acid. It mainly consists of a substance to which chemists have given the name of amylic alcohol, whose composition is represented by the formula $C_5H_{12}O$. It is a colourless limpid fluid, which has a persistent and oppressive odour and a burning taste. It is only sparingly soluble in water, but may be mixed with alcohol, ether, and the essential oils in all proportions. Any whisky which produces a milky appearance, when mixed with four or five times its volume of water, may be suspected to contain it. Fusel oil is principally sold in Britain for the purpose of yielding pear essence (amylic acetate) for the so-called jargonelle-drops. See ALCOHOL, WHISKY.

Fusible Metal, an alloy which melts at a temperature below that of boiling water. It consists of a mixture of several metals, of which bismuth is the most important. The following are examples:

Composition.	Melts at
4 bismuth, 2 lead, 1 tin, and 1 cadmium	60·5° C. (141° F.).
5 bismuth, 3 lead, and 1 tin	91·6° C. (197° F.).
8 bismuth, 5 lead, and 3 tin	94·5° C. (202° F.).

Both on account of its melting at a low temperature and of its property of expanding as it cools, fusible metal is valuable for several purposes in the arts. It is used in stereotyping, in taking casts of medals and of woodcuts, and in testing the finish of dies. It has also been employed for making anatomical casts, and a peculiar kind of it was used for making safety-plugs for steam-boilers. For the latter purpose it melts when the pressure of the steam becomes dangerously high. It was found, however, that the alloy underwent some change, by being kept long heated to near its melting-point, which rendered it unsuitable.

Fuze, a means of igniting an explosive at the required instant, whether it is used in blasting operations, military demolitions and mines, or as the bursting-charge of a shell or Bomb (q.v.). In the former cases electricity would generally be used, but for hasty military demolitions Bickford's fuze is employed in the British army. It is of two kinds—'instantaneous' and 'ordinary,' the first burning at 30 feet a second, the other at 3 feet a minute. The 'ordinary' consists of a train of gunpowder in layers of tape covered with gutta-percha; in the 'instantaneous,' which is distinguished by crossed threads of orange worsted outside, quick-match takes the place of the gunpowder. Powder hose is sometimes used when no other fuze is available. It is made of strips of linen, forming, when filled with powder, what is called a 'sausage,' ½ to 1 inch in diameter.

The fuzes used for shells are of a totally different character and of many patterns. They are of two classes, those which depend for their action upon the rate of burning of the composition in them, called 'time'-fuzes, and those which burst the shell on its striking the target, ground, or water, called 'percussion'-fuzes. In the British army time-fuzes are hollow truncated cones of beech-wood, carrying a column of fuze-composition which burns at a fixed rate—marks and figures on the outside show twentieths of a second or less, and indicate where the hole must be made by a fuze-borer in order that the flame may have access through it to the bursting-charge, and so open the shell at the desired instant during its flight. They are chiefly used with Shrapnel Shell (q.v.) and mortars. Their length varies from 3 to 6 inches, and they are fixed in to the head of the shell before firing. The thickness of iron would prevent the passage of the flame through the hole made by the borer in the shorter fuzes, and therefore two or more powder channels are made in them, parallel to the fuze-composition, to communicate its flame to the bursting-charge. In guns having windage the fuze is ignited by the flame of the cartridge enveloping the shell, and quickmatch is placed on the top of the fuze to facilitate this. A metal cover protects the quickmatch until the last moment, and is then torn off by means of a tape provided for that purpose. In guns having no windage a percussion arrangement is placed in the head of the fuze, so that the shock of discharge may ignite the fuze-composition. Fig. 1 shows a section of the common time-fuze, through one powder channel.

Fig. 1.

A section of the percussion-fuze designed in the Royal Laboratory at Woolwich is shown in fig. 2. It is a hollow gun-metal cylinder, *a*, arranged so as to screw into the head of the shell. Inside is a movable *pellet* or ring, *b*, of white metal driven with fuze-composition like a tube, and carrying a percussion-cap. It has four *feathers* or shoulders projecting from its sides, and above these a gun-metal *guard*, *c*, fits round the pellet loosely, so as to prevent the cap of the pellet coming into contact with a steel pin which projects downwards from the top of the fuze. A safety pin, *d*, goes through the fuze with the same object, but is removed before firing, and a lead pellet, *e*, then closes the aperture left by its removal. On discharge the shock causes the guard to shear off the feathers, and set back with the pellet against the bottom of the fuze. The shock of impact on the target or ground causes the pellet to set forward, bringing the cap against the pin, igniting the fuze-composition, and bursting the shell. Percussion-fuzes are chiefly used with 'common' Shell (q.v.).

Fig. 2.

Very many others are in use, chiefly modifications of these two types—e.g. the 'delay' action fuze has both a percussion and time arrangement, so as to burst the shell an instant after impact. All are delicate and apt to deteriorate hopelessly with age or exposure to damp. In the American pneumatic dynamite gun, the shell contains an electric battery, and the circuit is completed by the shell striking either water or the target.

Gallic Acid, $HC_7H_5O_5,H_2O$, is an acid which exists in small quantity in gall-nuts, in valonia (the acorn-cup of *Quercus ægilops*), in divi-divi (the pod of *Cæsalpinia coriaria*), in sumach, and other vegetables. It is usually prepared from gall-nuts, which, in addition to gallic acid, contain a large proportion of tannin (tannic acid or gallotannic acid). When the gall-nuts are digested with water for some weeks fermentation takes place, and the tannic acid is gradually converted into gallic acid. The same result is obtained more quickly if sulphuric acid be present. To obtain pure gallic acid the gall-nuts are boiled with water, and the hot liquor separated. On cooling gallic acid crystallises out, and is further purified by solution in hot water and treatment with animal charcoal.

It forms delicate, silky, acicular crystals, nearly colourless, and having a sourish taste. It is soluble in 3 parts of boiling water, but only in 100 of cold water, and on this account it can be readily purified by recrystallisation. With solution of iron salts (ferric) it produces a blue-black colour, and finally yields a black precipitate on exposure to the air. Hence it may be used in the production of ink, for which purpose it has some advantages over tannin or gall-nuts. When the crystals are strongly heated pyrogallic acid is produced and sublimes over. Gallic acid is a useful astringent. As it does not coagulate albumen it is readily absorbed into the blood, and in this way it is efficacious in Bright's disease. Where a decided local astringent effect is desired tannic acid is much more powerful.

Gallium (sym. Ga, eq. 69·8) is a metal discovered by M. Lecoq de Boisbaudran in 1875 in a zinc-blende found in the Pyrenees. It has also been found in blendes from Asturia and from Bensberg. Strange to say, its properties and its salts were predicted before its existence was known by Mendeleeff, in virtue of his Periodic Law (see ATOMIC THEORY, Vol. I. p. 332). Gallium is of a bluish-white colour, and has a specific gravity of 5·9. It possesses the remarkable property of fusing at 30·1° C. (76° F.), and remaining liquid when cooled down even to 0°. If, however, the globule of molten metal be touched with a fragment of solid gallium, it at once solidifies. Heated to bright redness in contact with air gallium does not volatilise, and only a very thin coat of oxide is formed on the surface. Gallium, which has no industrial importance, dissolves readily in hydrochloric acid and in caustic potash with evolution of hydrogen. It forms one oxide, Ga_2O_3, which is insoluble in water, but soluble in potash and ammonia. The chloride, nitrate, and sulphate are all very soluble in water; the sulphate combines with ammonium sulphate to form an alum.

Gallotannic Acid, a synonym of Tannic Acid (q.v.). See also GALLIC ACID.

Galvanised Iron. This name is given to iron which has been coated with zinc to prevent its rusting. The iron is simply dipped in the melted zinc, and the name does not imply, as might be supposed, that any definite galvanic process is undergone. Galvanised iron first came into use about 1837, when iron cooking-vessels were treated in this way. Since then tinned iron has come into use for cooking-vessels, and galvanised iron is now employed chiefly for roofing purposes, buckets, telegraph wire, chains, &c. The process of manufacture is very simple. The zinc is melted and dry sal-ammoniac poured on the top. This fuses and forms a protecting layer, keeping the surface of the metal clean. The iron plates or vessels, having been carefully cleansed by means of dilute hydrochloric acid and scrubbing with sand, are now introduced into the molten zinc, which immediately forms an alloy with the iron, and renders it incapable of rusting. Care must be taken not to immerse the iron for too long a time, for the alloy of zinc and iron melts at a comparatively low temperature, and there is a danger of destroying the vessel which is being galvanised. Galvanised iron is not so tough as iron itself, but still the freedom from rusting makes it specially applicable for many purposes. Galvanised iron water-pipes are now much employed in houses, but steam-pipes of this material are unsatisfactory; when exposed continuously to a moist steam heat, galvanised iron seems to become corroded, and small holes make their appearance. Galvanised iron is, of course, unsuitable where any acid is present, and any preparation containing vinegar will assume a disagreeable taste if placed in a galvanised vessel.

Gangrene (Gr. *gangraina*, 'a gnawing'), or MORTIFICATION, is the death of a part of the body, whether external or internal. It is most common in the extremities, especially the feet. Its immediate cause is always arrest or impairment of the supply of blood to the affected part. This may be produced in various ways: (1) by direct mechanical injury, or by extreme heat (burn) or cold (Frost-bite, q.v.); (2) by severe septic inflammation, usually following injury, or attacking a wound; (3) by disease of the blood-vessels of the part, in combination perhaps with weak heart action. The second group includes the most dangerous and fatal forms of gangrene: Cancrum Oris (q.v.), phagadæna, and hospital gangrene, now happily much less common than they once were. The third includes gangrene occurring as a result of poisoning by ergot of rye, of diabetes, old age, &c.

The symptoms and appearances attending gangrene vary greatly in different cases. Its onset may be sudden or gradual; it may at once become limited, or it may have a constant tendency to extend; it may be preceded and accompanied by great pain, or may only be observed in consequence of the local loss of feeling. But in all cases the loss of vitality is accompanied by loss of natural warmth, of sensibility and of motion in the affected part, and by a change in its appearance. It may either become moist and swollen, or dry and shrivelled; and its colour may be either dark purple or greenish, or at least at first pale and waxy. The constitutional symptoms are equally variable: if the part affected be small and not vital, and the gangrene limited, they may be slight and of little importance; otherwise there is generally great depression, with rapid feeble pulse, foul tongue, and other signs of alarming illness.

If the gangrene be limited, a separation takes place gradually between the living and dead parts, and, if the patient survive, the disorganised and lifeless texture is thrown off, and the part heals by Cicatrisation (q.v.) or the formation of a scar, indicating the loss of substance. With regard to treatment, the strength must, generally speaking, be maintained by a nourishing but not too stimulating diet, and the part carefully preserved from external injury and from changes of temperature.

In some forms of gangrene amputation may afford the best or even the only chance of saving the patient's life; in others its results are disastrous, as it is almost certain to lead to fatal extension of the disease. Much care is therefore needed in deciding the question whether surgical interference should be resorted to.

Garlic, OIL OF. When the leaves, seeds, or bulbs of garlic and other allied plants are distilled with steam, about 0·2 per cent. of a brown oil, with acrid taste and strong disagreeable odour, passes over. By purification it is obtained as a pale yellow oil having the odour of garlic, and it is then found to consist of the sulphide of allyl, $(C_3H_5)_2S$. This oil is nearly related to the pungent oil of mustard, C_3H_5NCS, an isomer of the sulphocyanide of allyl, and is of much interest chemically, but it is of no importance from an industrial or popular point of view.

Gelatine, in Chemistry. Little is yet definitely known of the chemical nature of gelatine. It consists approximately of carbon 49·6, oxygen 25·4, nitrogen 18·3, and sulphur about 0·1 per cent. It is soluble in hot water, in acetic acid, and in cold sulphuric acid, and is insoluble in alcohol, ether, and other organic liquids; the aqueous solution is precipitated by tannic acid, chrome alum, and corrosive sublimate, but not by most acids, salts, or alkalies in dilute solution. Gelatine may be purified by dissolving it in water and pouring the solution into a large bulk of alcohol; the clot which forms consists of nearly pure gelatine, containing only a trace of ash. By dry distillation gelatine yields a quantity of carbonate of ammonia, and a foul smelling brown oil containing carbonate, sulphide and cyanide of ammonia, aniline, methylamine, picaline, and a number of pyridine bases. Gelatine solution dissolves lime and calcium phosphate much more freely than cold water, forming with the latter a definite compound, which probably forms part of the tissue of bones.

In Technology, the term gelatine, although usually applied to only one variety of the substance obtained by dissolving the soluble portion of the gelatinous tissues of animals, nevertheless properly belongs also to Isinglass (q.v.) and Glue (q.v.), which are modifications of the same material. Vegetable jelly is also analogous. Gelatine and glue signify the more or less pure and carefully prepared jelly of mammalian animals; but the term isinglass is only applied to certain gelatinous parts of fishes, which from their exceeding richness in gelatine, are usually merely dried and used without any other preparation than that of minute division for the purpose of facilitating their action.

Gelatine proper is prepared for commercial purposes from a variety of animal substances, but chiefly from the softer parts of the hides of oxen and calves and the skins of sheep, such as the thin portion which covers the belly, the ears, &c.; also from bones and other parts of animals. One of the best, if not the best of the varieties of gelatine manufactured in Great Britain, is the 'sparkling gelatine' of Messrs Cox of Gorgie, near Edinburgh, which is remarkable for its great purity and strength, or gelatinising power, and is purified by processes patented by them. The materials they use are carefully selected portions of ox only imported from South America. Another preparation, made by Mackay of Edinburgh from calves'-feet, is deserving of special mention.

The general method adopted with skin-parings or hide-clippings is first to wash the pieces very carefully; they are then cut into small pieces and placed in a weak solution of caustic soda for a week or ten days. When this process of digestion has been sufficiently carried on, the pieces of skin are then transferred to revolving cylinders supplied with an abundance of clean cold water, and afterwards are placed still wet in another chamber lined with wood, in which they are bleached and purified by exposure to the fumes of burning sulphur; they next receive their final washing with cold water, which removes the sulphurous acid. The next operation is to transfer them to the gelatinising pots. Water is poured in with the pieces, and kept at a high temperature by means of the steam in the cases surrounding the pots.

By this means the gelatine is quite dissolved out of the skin, and is strained off whilst still hot; it is poured out in thin layers, which as soon as they are sufficiently cooled and consolidated are cut into small plates, usually oblong, and laid on nets, stretched horizontally, to dry. It is then cut into shreds and is ready for market.

Another process, introduced by Mr Swineburne, consists in treating pieces of calfskin by water alone, without the soda and sulphur processes; the pieces, after simple washing, being transferred at once to the pots to be acted upon by the steam. Inferior gelatine is made from bones and other parts of animals; and it is understood that the enormous number of rats killed in the sewers and abattoirs of Paris are used by the gelatine-makers. The French manufacturers succeed better than any others in clarifying these inferior gelatines, and they rarely make any others; they run their plates out very thin, which gives them greater transparency; and they colour them with most brilliant colours, and form very fine-rolled sheets, tempting the eye with an appearance of great delicacy and purity.

Gelatine should never be judged by the eye alone. Its purity may be very easily tested thus: soak it in cold water, and then pour upon it a small quantity of boiling water; if pure it will form a thickish, clear, straw-coloured solution, free from smell, but if made of impure materials it will give off a very offensive odour, and have a yellow gluey consistency. No article manufactured requires such careful selection of material and such nice and cleanly manipulation to ensure a good marketable character; and those anxious for purity should avoid all artificially coloured varieties, however temptingly got up, unless they are required for merely decorative purposes and not for food. Of late years the commercial uses have greatly increased. Gelatine is the foundation of the dry-plate system of photography, and by its means the science has been revolutionised and its capabilities extended to an extraordinary degree. To the printing process as employed by Messrs Goupil of Paris and others the world is indebted for cheap and at the same time highly artistic copies of many admirable pictures. It is further very extensively used by druggists for coating pills and nauseous drugs, liquid and solid, which are thus rendered tasteless; and by confectioners for some kinds of sweetmeats. For the value of gelatine as food, see DIET; and for applications of gelatine to the purpose of book illustration, see ILLUSTRATION. See also PHOTOGRAPHY.

One of the qualities of gelatine is its power to form chemical combinations with certain organic matters; hence, when it is mixed and dissolved in a fluid containing such matters, it combines, and the compound is precipitated. It would appear that this combination, however, is threadlike in its arrangement, and that the crossing threads form a fine network through the fluid, which, in falling, carries down all floating substances that by their presence render the liquid cloudy; hence its great value in clarifying beer and other liquids. For this reason isinglass, which has been found the best gelatine for the purpose, is very largely consumed by brewers.

Various kinds of animal food are valued for the abundance of gelatine they contain, as the Trepang and Bêche-de-Mer (species of Holothuria), sharks' fins, fish-maws, ray-skins, elephant hide, rhinoceros hide, and the softer parts, all of which are luxuries amongst the Chinese, Japanese, Siamese, Malays, &c. Turtle-shells, or the upper and lower parts of the shield (*carapace* and *plastron*), constitute the callipash and callipee of the epicure, and form, in the hands of the experienced cook, a rich gelatinous soup. The fleshy parts of the turtle, calves' head and feet, and many other things might be enumerated as valuable chiefly in consequence of their richness in this material.

Gentian (*Gentiana*—so called after the Illyrian king Gentius, who is said by Pliny to have introduced *G. lutea* into medicine), a genus of Gentianaceæ. There are more than 100 species, natives of north temperate regions, very often growing in high mountain pastures and meadows, which they cover with their beautiful blue or yellow flowers. The roots of the Common Gentian or Yellow Gentian (*G. lutea*) are collected by the peasants of the Alps (along with the less valuable roots of *G. pannonica*, *purpurea*, and *punctata*) to furnish the gentian root (*radix gentianæ*) of pharmacy, which is largely employed as an excellent bitter and stomachic. The medicinal properties are essentially due to the presence of a bitter glycoside (*gentiopicrin*); pectin (see FRUIT) and also sugar are present in quantity; hence the peasants of the Alps prepare alcoholic bitters—their *Enziangeist*—by the fermentation of the fresh roots. *G. Catesbæi* is used as gentian root in North America, and *G. Kurroo* in the Himalayas.

The florist recognises two main groups of these beautiful hardy plants, the first strong and easily grown in borders, of which the Willow Gentian (*G. asclepiadea*) and *G. lutea* are specially common. The former can also be grown with good effect under trees and among grass. The dwarf kinds require more careful treatment, with the exception of the Common Gentianella (*G. acaulis*), which readily forms edgings and carpets. The name Gentianella is sometimes also applied to the allied *Cicendia filiformis*, a small, slender, and graceful plant with yellow flowers. *G. verna* (Vernal Gentian) can be grown well in deep sandy loam, with abundant moisture and sunshine. Bavarian Gentian (*G. bavarica*) and Crested Gentian (*G. septemfida*) of the Caucasus require more moisture. Other species can be cultivated with care. Of North American species *G. crinita* is specially celebrated for the beauty of its flowers; the genus in fact may fairly be allowed the very first place among the floral glories alike of Alpine regions, in which they range up to the snow-level, and of the alpine garden. Several species of Gentian are popularly called *Baldmoney*. See ALPINE PLANTS.

Crested Gentian (*Gentiana septemfida*).

Gentianaceæ form an order of corollifloral dicotyledons. The 500 species are almost exclusively herbaceous, and are usually natives of temperate and cold latitudes and altitudes. Many have flowers of great beauty, and a general astringency pervades the order, whence many are of past or present medicinal repute.

Gilding. There are many processes of gilding, varying with the nature of the substance to be gilded, and the kind of effect required to be produced, but they may all be classified under three heads—viz. (1) mechanical gilding, (2) chemical gilding, (3) encaustic gilding.

The first is used chiefly for gilding wood, plaster of Paris, leather, paper, and other substances. If the object to be gilt is a picture or mirror frame, consisting of a plain wooden moulding, then, after getting a coat of oil-paint, from four to ten coats of fine whiting mixed with fine glue are put on, each in its turn being smoothed with pumice-stone and fine sand-paper. This done, a coat of gold-size is given to those parts which are not to be burnished; but those which are receive only a coating of clear animal size. Both of these prepared surfaces now receive the gold-leaf, which is laid on by means of a broad thin brush called a *tip*, and further pressed on with a thick soft-haired brush. Those parts which have been gold-sized are in this way oil-gilt, and will stand washing; while such portions as have been gilt on the size preparation in order to be burnished will not bear soap and water. If the picture-frame is much enriched with fine raised ornament, the surface to be gilt is previously prepared with oil-paint and gold-size alone, as the coating with whiting destroys the sharpness of the work. The result, however, is more tender and less durable.

Japanner's Gilding.—Where gilt ornaments are to be put on a japanned ground, they are, by one method, painted with gold-size, and gold-leaf afterwards applied. By another method, rather more than the space the ornament is to occupy is wholly covered with gold-leaf, adhering with isinglass. The ornament is then painted on with asphaltum, which protects the gold beneath it while the superfluous leaf is being washed away. A little turpentine will then remove the protecting asphaltum so as to display the gilt ornament. Japanners' gold-size is a mixture of linseed-oil, gum-animi, and vermilion.

False Gilding, although an old invention, has become in recent years an important trade in Germany. The moulding intended to be 'gilt' in this way is first covered with bright silver-leaf or tinfoil on a surface prepared as above, and then coated with a yellow varnish. Other substitutes for genuine gilding that are largely used consist in applying 'Dutch gold,' which is copper beaten out like gold-leaf, as in genuine gilding, or in using so-called 'gold paint,' which is finely powdered brass or other similar alloy.

Chemical Gilding.—Metals are now usually gilded by the process of electro-gilding (see ELECTRO-METALLURGY); but, besides this, various methods of chemical gilding have been adopted, and some are still in use.

Water or Wash Gilding, as it is somewhat inappropriately termed, consists in applying to metal a paste formed of an amalgam of gold, and afterwards evaporating the volatile mercury by heat, which leaves the gold firmly adhering to the surface of the metal.

Gilding by Immersion.—For this purpose a solution of gold in nitro-muriatic acid is used which slowly attacks the metal to be gilded, and at the same time deposits on its surface an equivalent of gold. The method called *Grecian Gilding* is another similar process, in which gold is used dissolved in a solution of sal-ammoniac and corrosive sublimate in nitric acid.

Most articles that are gilded by either of the above chemical methods, or by electro-gilding, are submitted to an after-process of *colouring*. This consists either in acting upon the surface with a saline solution, and heating the article afterwards, or in coating it with a kind of varnish of beeswax and yellow ochre, and then burning this off. The colouring of jewelry, &c., made of gold alloyed with copper or brass, is performed by submitting the article to the action of a mixture of nitre, alum, and common salt, either dry or dissolved in water, heat being applied in either case. The baser alloy is thus removed from the surface, which becomes covered with a richly coloured film of nearly pure gold.

Sword-blades, lancets, and other steel articles are gilded in fancy devices by drawing the design with a camel-hair pencil moistened in a solution of gold, prepared by agitating ether with a solution of terchloride of gold, and decanting the light liquid which floats on the top.

Silks, artificial flowers, ivory, bone, &c. may be gilded by immersing them in, or painting them with, a neutral solution of one part of terchloride of gold to four or five of water, and then exposing them in a vessel containing hydrogen gas, which readily combines with the chlorine, and reduces the gold to the metallic state.

Encaustic Gilding is usually applied to glass and porcelain. The gold is first obtained in a finely divided state by precipitating from the chloride with protosulphate of iron, or by simply heating the chloride. This powder is ground up with $\frac{1}{15}$th of its weight of oxide of bismuth and some borax and gum water, and then painted on the ware. It is then heated till the borax is vitrified and the gold thereby fixed. Sometimes the gold is ground with turpentine, or an amalgam of gold is used. This has a brown dingy appearance when it leaves the kiln; the gold lustre is brought up by burnishing.

Gilding Metal.—The metal of which gilded goods are made is required to have as nearly as possible the colour of gold, so that when the surface-gilding is worn off at the more exposed parts the difference of colour will not be readily apparent. This is obtained by making a kind of brass having a much larger proportion of copper than common brass. The following are three receipts from among a variety in use: (1) 6 parts copper, 1 common brass; (2) 4 parts copper to 1 Bristol brass; (3) 13 parts copper, 3 parts brass, 12 parts tin. The last is much harder than No. 1 or 2.

Gin, or GENEVA, an alcoholic drink, distilled from malt or from unmalted barley or other grain, and afterwards rectified and flavoured. The gin which forms the common spirituous drink of the lower classes of London and its vicinity is flavoured very slightly with oil of turpentine and common salt. Each rectifier has his own particular recipe for regulating the quantities to be used, but usually about 5 fluid ounces of spirit of turpentine and 3½ lb. of salt are mixed in 10 gallons of water; these are placed in the rectifying still, with 80 gallons of proof corn spirit, and distilled until the feints begin to come over. The product is then used either unsweetened or sweetened with sugar. Potato spirit is used in the manufacture of inferior qualities of gin.

The word *gin* is a shortened form of *geneva*, so called by confusion with the Swiss town of Geneva, but itself really a corrupted form of the Old Fr. *genevre*, 'juniper,' from the Lat. *juniperus*. It is well known that juniper-berries are still used in flavouring the spirit made from rye-meal and malt in Holland, where it is an article of great manufacture, chiefly at Schiedam; hence it is often called *Schiedam* or Hollands, as well as geneva and gin. The larger part by far of the spirit made in Holland is exported to other countries, especially to North America and northern Europe. It was formerly always exported in bottles, a square form of which is still familiar, but casks are now much used as well.

Almost every gin-palace keeper in London has some vile recipe for increasing the pungency and giving a factitious strength to the much-diluted sweetened spirit sold under this name. A mere enumeration of the articles usually employed will give some idea of the extent to which sophistication is carried on with this spirit: roach alum, salt of tartar (carbonate of potash), oils of juniper, cassia, nutmeg, lemons, sweet fennel, and caraway, coriander seeds, cardamoms, and capsicums, and, it is alleged, even sulphuric acid. Excess of turpentine is the most common and perhaps the worst adulterant. Still much sound gin is made in London—the diuretic qualities of its 'Old Tom,' as well as of Hollands, are well known.

Ginger (*Zingiber*), a genus of Zingiberaceæ, of which most species yield root-stocks useful as condiments and stomachics, especially the narrow-leaved or common ginger (*Z. officinale*), which has been

Common Ginger (*Zingiber officinale*): *a*, plant with leaves and flowering stems; *b*, a flower; *c*, portion of leafy stem. (From Bentley and Trimen.)

cultivated in the East Indies from time immemorial, and is now also cultivated in other tropical countries, particularly the West Indies and Sierra Leone, from both of which, as well as from the East Indies, its root-stocks—the ginger of commerce—are a considerable article of export. The cultivation is extremely easy, and is carried on up to 4–5000 feet in the Himalayas in moist situations. The root-stock is taken up when the stems have withered, and is prepared for the market either simply by scalding in boiling water—in order to kill it—and subsequent drying, or by scraping and washing. The first method yields *Black Ginger*, the second *White Ginger*; but there are considerable varietal differences in the shades of these. The blackest of Black Ginger, moreover, is only of a stone colour, and the whitest of White Ginger very far from perfectly white, unless bleaching by chloride of lime be afterwards employed to improve its appearance—a process not otherwise advantageous. The uses of ginger, both in medicine as a stimulant and carminative, and in domestic economy as a condiment, are too well known to require particular notice. It contains a good deal of starch, but its main qualities depend upon its pale yellow volatile oil. *Preserved Ginger*, largely imported from China and the East and West Indies, consists of the young root-stocks preserved in syrup; it is not only a delicious sweetmeat, but a useful stomachic. The young root-stocks are often also candied.—Ginger was known to the Romans, and is said by Pliny to have been brought from Arabia.—Zerumbet (*Z. zerumbet*), also called Broad-leaved Ginger (and sometimes erroneously Round Zedoary), is cultivated in Java; its root-stock is much thicker, but less pungent.—Cassumunar (*Z. cassumunar*), sometimes called Yellow Zedoary, has a camphor-like smell, and a bitter aromatic taste. It was of high reputation as a medicine about the close of the 17th century.—Mioga (*Z. mioga*) is less pungent than ginger, and is used in Japan.—Cattle sent to graze in the jungles of northern India, during the rainy season, are supplied with the root-stocks of *Z. capitatum*, to preserve their health.—The root of *Aristolochia* (q.v.) *canadense*, sometimes called *Indian Ginger* or *Wild Ginger* in North America, is applied to similar uses.

Essence of Ginger, much used for flavouring, is merely an alcoholic tincture.—*Syrup of Ginger* is used chiefly by druggists for flavouring.—*Ginger Tea* is a domestic remedy very useful in cases of flatulence, and is an infusion of ginger in boiling water.—*Ginger-beer* is an effervescing drink made by fermenting ginger, sugar, and some other ingredients, and bottling before the fermentation is completed.—*Ginger Wine* or *Ginger Cordial* is a liqueur flavoured with ginger.—*Ginger Ale* is one of the Aerated Waters (q.v.).—*Gingerbread* is a very well known article of food, which in the 14th century was made of rye dough, kneaded with ginger and other spice, and honey or sugar. Now its constituents are treacle, moist sugar, wheaten flour, butter, and eggs, flavoured with ginger and other spices; a little carbonate of magnesia and tartaric acid, or carbonate of ammonia, are sometimes put in to give lightness.

Ginseng, a root highly esteemed in China as a medicine, being universally regarded as possessing the most extraordinary virtues, and as a remedy for almost all diseases, but particularly for exhaustion of body or mind. It is the root of a species of Panax (order Araliaceæ), appropriately so called since so typical a panacea. *P. Ginseng* of Chinese Tartary is, however, scarcely distinct from *P. quinquefolium* of North America, which is exported to China to the amount of about 500,000 lb. annually, but fetches a lower price. The ginseng of Corea is most valued, and is carefully cultivated in that country. It is raised from seed; the seedlings are planted out, and frequently transplanted, and it is not till the fifth year that the plant reaches maturity. Ordinary ginseng is prepared by simply drying the root over a charcoal fire; the red or clarified ginseng is steamed in earthenware vessels with holes. The root is mucilaginous, sweetish, also slightly bitter and aromatic. It has been regarded as a very elixir of life all over the East, but especially in China and Japan. Western medical practitioners, however, have as yet failed to confirm or explain its extraordinary reputation among the Chinese. The export from Corea, amounting to 27,000 lb. in a good year, is a strict monopoly. The wild ginseng of Corea has frequently fetched twenty times its weight in silver in China. *P. fruticosum* and *cochleatum* of the Moluccas are fragrant aromatics used in Indian native medicine.

Glauber, JOHANN RUDOLPH, a German alchemist and physician, was born at Karlstadt, in Franconia, in 1603 or 1604, and died at Amsterdam in 1668. No details regarding his life are known, except that he resided at Vienna, Salzburg, Frankfort-on-the-Main, and Cologne, from whence in 1648 he removed probably to Amsterdam. Although a believer in the philosopher's stone and in the elixir vitæ, he contributed very materially to the progress of chemistry. In 1648 he discovered hydrochloric acid whilst experimenting with oil of vitriol and common salt; he was probably the first to procure nitric acid; and his name has been transmitted in Glauber's Salt, which he likewise discovered. His treatises were published at Amsterdam in 7 vols., 1661; and an English translation was printed by Parke at London in 1689.

GLAUBER'S SALT is the popular name of the neutral sulphate of soda whose chemical composition is represented by the formula $Na_2SO_4 + 10H_2O$. It occurs in long four-sided translucent prisms, terminated by dihedral summits, and containing ten atoms of water. On exposure to the air, the crystals lose all their water, and become resolved into a white powder. When heated they readily melt in their water of crystallisation; and, if the heat is sufficiently continued, the whole of the water is expelled, and the anhydrous salt remains. Glauber's salt has a cooling, bitter, and saltish taste; it is readily soluble in water; its solubility (in the ordinary crystalline form) increasing up to 92°, when it appears to undergo a molecular change, and to be converted into the anhydrous salt, which at this temperature is less soluble than the hydrated compound, and separates in minute crystals. Glauber's salt is a constituent of many mineral waters (as at Carlsbad and Cheltenham), and is found also as an efflorescence about saline lakes in some parts of the United States; and it occurs in small quantity in the blood and other animal fluids.

The anhydrous salt is prepared in enormous quantity from common salt and oil of vitriol, with the view of being afterwards converted into carbonate of soda (see SODA). For medical use a purer form is required. The salt which remains after the distillation of hydrochloric acid—this salt being sulphate of soda contaminated with free sulphuric acid—is dissolved in water, to which is added powdered white marble (carbonate of lime), to neutralise the free acid, and to precipitate it as an insoluble sulphate; the solution is boiled down till a pellicle appears, is strained, and set aside to crystallise.

It is used as a common purgative, and is especially applicable in fevers and inflammatory affections, when it is necessary to evacuate the bowels without increasing or exciting febrile disturbance. The usual dose is from half an ounce to an ounce; but if it is previously dried, so as to expel the water of crystallisation, it becomes doubly efficient as a purgative. It is now much less frequently used in domestic medicine than formerly, having given place to milder aperients.

Glue is merely an impure *Gelatine* (q.v.). Almost every animal substance will yield it, hence all kinds of animal refuse find their way to the glue-makers' boilers. The refuse of tanneries, consisting of the clippings of hides, hoofs, ear and tail pieces of ox, calf, and sheep are preferred, because they can be dressed with lime, which removes the hair, and acts as an antiseptic. For this purpose they are placed in tanks with quicklime and water for two or three weeks. They are afterwards washed and dried, and are ready for use by the glue-maker, who usually gives them another heavier lime-dressing, and subsequently washes them; they are afterwards exposed to the action of the air for a time, to neutralise the caustic lime. When well drained, the pieces are placed in flat-bottomed copper-boilers, which have a perforated false bottom placed a little distance above the true one, to prevent the burning of the materials, and which have been supplied with rain or other soft water up to two-thirds the depth of the boiler, the pieces being piled up to some height above the top of the open boiler. The whole is kept at a gentle boiling heat until all the gelatinous part has dissolved out, and the mass of material has sunk down into the fluid. The boiling is sustained until, by repeated trials of small quantities, the operator knows the fluid is of the right consistency, when it is drawn off carefully into the congealing boxes.

The congealing boxes are of wood, and are nearly square, being slightly narrower at the bottom than the top; they are filled to the brim, and when their contents are sufficiently solidified the glue, with a little management, turns out in the form of a cube, which is cut into thin slices by a wire in the same manner as soap; and these larger slices are subdivided into smaller cakes by a wet knife. Frames, with nets stretched upon them, are provided for drying the cakes upon; and these frames, when covered with the cakes of glue, are adjusted one over another at a little distance apart, supported between four uprights, and, if in the open air, covered over with little wooden roofs, the whole being arranged so that the air can have free access to facilitate drying. This process is an anxious one for the manufacturer, as the changes of the weather have great and often completely destructive effects upon glue in this state. In Britain spring and autumn are the best drying seasons. Generally, after the open-air drying, the glue is taken to drying-rooms, heated slightly, where it hardens effectually; but it is not yet finished; the cakes at this stage have a dull, unsightly look, to remedy which they are dipped into cold water, or are wetted with a brush dipped in hot water, and redried, this wetting giving the cakes a bright varnished appearance.

While England does not excel in this manufacture, it is a recognised fact that Scottish glue—such as that made by Messrs Cox at Edinburgh—ranks in the front of the glues of all countries. A light-coloured glue is not necessarily good, nor dark-coloured glue necessarily bad. A bright clear claret colour is the natural colour of hide-glue, which is the best and most economical. Light-coloured glues (as distinguished from gelatine) are made either from bones or sheepskins. The glue yielded by these materials cannot compare with the strength of that yielded by hides. A great quantity is now made in France and Germany from bones. It is got as a by-product in the manufacture of animal charcoal. Although beautiful to look at, it is found when used to be far inferior to Scottish hide-glue. The latter is largely used by match-makers, piano-makers, and cabinet-makers, who export their goods to all parts of the world, and to whom, owing to the damp climates of many parts to which they export, a first-class glue is absolutely necessary. Besides its use in joinery, cabinet-making, book-binding, match-making, and similar operations, glue is used by paper-makers and in dressing silks; and for these last two purposes fine light-coloured kinds in thin cakes are made. Large quantities are employed by paper-hangers and others for sizing walls. It is also used for stiffening straw, cotton, horsehair, and other plaits for making bonnets and hats.

Marine Glue is not a glue, but a cementing composition used in shipbuilding, for paying seams in ships' decks after being caulked. In hot climates it is preferred to tar for this and other purposes, where the materials are exposed to the influence of wet. It consists of india-rubber cut very small, and digested at a gentle heat in a closed vessel with coal-tar naphtha until it is dissolved, when powdered shell-lac is added, and the digestion continued until it also is dissolved.

Gluten is one of the most important constituents of the varieties of corn used as food. It is obtained by mixing flour with water, and thus forming a paste or dough. This paste is placed in a bag of fine linen, and kneaded in water, which must be repeatedly changed till it ceases to assume a milky appearance. A gray, tenacious, viscous, tasteless substance, having the appearance of bird-lime, is left in the bag. This substance consists mainly of gluten, mixed with traces of bran starch and of oily matter. The gluten thus obtained from wheat and from rye is far more tenacious than that which is obtained from the other cereals, and it is the great tenacity of this constituent that especially fits these flours for conversion into bread. It is found by analysis that the proportion of gluten (16 per cent.) contained in wheat grown in Algeria and other hot countries is considerably higher than in wheat grown in England (10·7 per cent.), or still colder countries; the proportion in the wheat of the United States seems to vary from 9·85 to as much as 15·25 per cent.; and the hard, thin-skinned wheats contain more of this ingredient than the softer varieties of the grain.

Gluten in a moist state rapidly putrefies, the mass acquiring the smell of decaying cheese; but when dry it forms a hard, brownish, horny-looking mass, that does not very readily decompose. On treating gluten with hot alcohol, we find that it resolves itself into at least two distinct substances, one of which is soluble, and the other insoluble in that fluid. The insoluble portion—vegetable fibrin—is a gray, tough, elastic substance, insoluble in water or in ether, but readily soluble in dilute alkalies, from which it is precipitated by neutralisation with acetic acid. The soluble portion is in part precipitated from the alcohol on cooling, in the form of flakes, which have the composition and properties of casein—a vegetable casein; while a third substance, *gliadin*, remains in solution, giving to the alcohol a syrupy consistence, but separating on the addition of water, as a white substance resembling albumen. All these constituents of gluten contain carbon, hydrogen, nitrogen, oxygen, and sulphur, in much the same proportion as the animal albuminates or protein bodies, and they all doubtless belong to the flesh-forming group of foods.

The action of gluten in the manufacture of bread is probably a double one; it induces, by constant action, an alteration of the starch, and subsequent fermentation, while by its tenacity it prevents the escape of carbonic acid gas.

Glycerine, GLYCEROL, or PROPENYL ALCOHOL, $C_3H_5(OH)_3$, was discovered by Scheele in 1779, who obtained it in the preparation of lead-plaster, and named it 'the sweet principle of fats.' It is a colourless, viscid, neutral, inodorous fluid, of an intensely sweet taste, is soluble in water and alcohol in all proportions, but is insoluble in ether and in chloroform. Its specific gravity is 1·27. If quickly cooled down, glycerine does not crystallise, but solidifies at 40° C. into a gum-like mass. In the winter of 1867 it was discovered that some glycerine which was being shipped to England had frozen into a solid crystalline mass; till then glycerine was believed to be uncrystallisable. At 100° it is slightly volatile, but if distilled alone the greater part of it becomes decomposed; it may, however, be distilled without alteration in a current of superheated steam. By this means Wilson succeeded in 1854 in separating heated fats into glycerine and the acid with which it was previously in combination; the glycerine is thus obtained in a high state of concentration as a colourless, syrupy liquid, which can be thus prepared in unlimited quantity.

Glycerine occurs ready formed in a few fats (as, e.g., old palm-oil), and, according to Pasteur, is contained in all fermented liquors, and especially in wine. It is a product of the saponification of the various fats. See SOAP.

Glycerine is a triatomic alcohol—i.e. it is derived from three molecules of water by replacing three atoms of hydrogen by the triatomic radical C_3H_5; or it may be considered a compound of C_3H_5 with three molecules of hydroxyl, OH—and may be represented by the formula $C_3H_5(OH)_3$; and in the animal and many vegetable fats, the three molecules of hydroxyl are replaced by three molecules of the anhydrous fatty acid. In the saponification of these fats—that is to say, when they are treated with potash, soda, or oxide of lead, or under the influence of superheated steam—the fatty acid separates from C_3H_5, which assimilates three molecules of hydroxyl and becomes glycerine. Glycerine forms soluble compounds with baryta, strontia, and lime; and it dissolves oxide of lead and numerous salts. It is found that glycerine is convertible into a true fermentable sugar when treated with a mixture of potassium bichromate and sulphuric acid, or with potassium permanganate in presence of sunlight.

We have already referred to the best mode (Wilson's process) of obtaining glycerine on a large scale; the usual method of obtaining it on a small scale is from olive-oil, which is saponified by treating it with an equal weight of litharge (lead oxide). This is mixed with water, and added to the oil, with which it is boiled till the saponification is complete. The glycerine is dissolved by the water, and is easily separated from the insoluble lead-plaster (a mixture of oleate and palmitate of lead). Any traces of lead are removed by sulphuretted hydrogen, and the water is expelled *in vacuo*, as the glycerine would turn brown in the open air.

The uses of glycerine are numerous. In medicine it is employed as a local application in diseases of the skin and of the ear; it is used as a solvent for many drugs; and is taken internally for the same purposes as cod-liver oil. It is a valuable preservative fluid for small and delicate anatomical preparations, and it has been applied to the preservation of meat. It is used in perfumery, in calico-printing, and in the preparation of leather. It is used by the wine-dealer to 'improve' the quality of wine, and by the brewer, as it is said, to impart keeping power to beer. Very large quantities of glycerine are required for the production of Nitro-glycerine (q.v.) and other explosives. It has been added to the water in gas-meters with the view of preventing it from freezing. It is used in the manufacture of copying-ink, and is of general application where a lubricating agent is required.

Like the alcohols in general, to which class glycerine belongs, it forms several classes or series of derivatives, the most important of which are its combinations with acids, which are analogous in their composition to the various fats and oils. See Roscoe and Schorlemmer's *Treatise on Chemistry*, and Schorlemmer's *Manual of the Chemistry of the Carbon Compounds*.

Glycocoll, or AMIDO-ACETIC ACID, $CH_2(NH_2)CO_2H$, was first prepared by Braconnot in 1820, being obtained among the products of the action of sulphuric acid on glue, and received from him the name *sucre de gélatine*, on account of its sweet taste. It is a product of various processes of decomposition of animal matters. Glycocoll is very soluble in water, the solution having no effect on vegetable colours, but it is insoluble in alcohol. Glycocoll combines both with acids and bases, and the compounds in both cases are soluble and crystallisable.

Glycogen, $C_{12}H_{20}O_{10}.H_2O$, sometimes called animal starch, was discovered by Claude Bernard in the human liver as well as that of graminivorous animals. It has been shown to exist very widely diffused throughout the animal kingdom, and appears to be an essential accompaniment of cellular growth, occurring in large quantities in the foetus. It occurs also in blood and muscular tissue. It is found in mollusca, dried oysters being said to contain as much as 9·5 per cent. Glycogen has also been detected in the vegetable kingdom, in moulds and other fungi. Its uses in the animal economy are noticed in the article LIVER.

Glycol is the type of a class of artificial compounds, whose existence was inferred, and afterwards discovered, by Wurtz. In their chemical relation and properties they form an intermediate series between the monatomic alcohols, of which common alcohol is the type, on the one hand, and the triatomic alcohols, a class of bodies of which ordinary glycerine is the type, on the other. The name of glycol, formed from the first syllable of glycerine and the last of alcohol, has been given to express this relation. The glycols are accordingly termed diatomic alcohols. Ordinary glycol is formed from ethylen, C_2H_4, and hence may be called ethyl-glycol, to distinguish it from propyl-glycol, which is formed from propylen, C_3H_6, from butyl-glycol, which is formed from butylen, C_4H_8, or from amyl-glycol, which is formed from amylen, C_5H_{10}. Glycol is a colourless, slightly viscid fluid, with a sweet taste, and its composition is expressed by the formula $C_2H_4(OH)_2$. See Schorlemmer's *Manual of the Chemistry of the Carbon Compounds*.

Goitre (Fr.), or BRONCHOCELE, the name applied to any enlargement of the Thyroid Gland (q.v.) which is not either inflammatory or cancerous. The commonest and most interesting form of the disease is that which is *endemic* in certain districts, particularly in mountainous regions—e.g. among the Alps, the Himalayas (as at Darjeeling), and the Andes. In Britain it is most often met with in Derbyshire, and hence popularly called 'Derbyshire neck;' but even there it is not common. In some villages among the Alps all the inhabitants without exception are affected. Endemic goitre is often associated in the same districts and the same families with Cretinism (q.v.). Numerous theories have been advanced to account for it; it has been attributed to damp climate, snow-water, water with excess of lime or of magnesia, bad feeding, bad ventilation, and many other influences. But no one of these alleged causes is present in marked degree in all affected localities: it seems probable that various different combinations of causes are capable of producing a similar effect on the thyroid.

Sporadic cases of goitre, indistinguishable as regards the swelling from the endemic form, except that they do not attain such a large size, occur in all parts of the world. In either case, the enlargement may affect all the tissues of the gland equally, or may have its chief seat in the blood-vessels or the fibrous tissue, or may be much exaggerated by the formation of Cysts (q.v.) in the gland. In that form called *Exophthalmic* goitre, or Graves's disease, after its first describer, the thyroid enlargement is vascular and pulsating, and is associated with protrusion of the eyes, rapid action of the heart, &c., and is clearly only one symptom of a wide disturbance of the nervous system.

In other forms of goitre the tumour produces as a rule no obvious ill effects, except the inconvenience arising from its size, for it may be so large as to hang down upon the breast, or even to admit of being thrown over the shoulder. In some few cases, however, where it does not project so much forward, it is apt to press upon the windpipe, embarrassing the respiration, and may even cause death in this way.

Endemic goitre may usually be cured or checked by removal at an early stage of the malady to an unaffected district and more healthy surroundings. Where this is not practicable, and in sporadic cases, iodine is the favourite remedy, both applied locally and administered internally; but no method is uniformly or certainly successful in the reduction of the enlargement. In bad cases the gland has frequently been removed; but the evil results which are now known often to follow (see MYXŒDEMA) have made surgeons, during late years, most unwilling to undertake the operation, itself a serious one. Partial removal is not open to the same objection; nor is division of the tumour in the middle line without removal. Both these proceedings sometimes give great relief, and may be followed by shrinking of the remaining gland substance.

Gold-beater's Skin, a very thin but tough membrane prepared from the external coat of the cæcum—a part of the great intestine—of the ox. It is drawn off in lengths of 25 inches or more from the other coats, immersed in a weak solution of potash, and scraped with a blunt knife upon a board. After a soaking in water, two of these pieces are stretched upon a frame, dried, and then separated by a knife. Each strip is again fixed with glue to a frame, and washed over with a solution of alum. When dry it is next coated with fish-glue, and afterwards with white of egg. The piece of membrane is then cut into squares of 5 or 5½ inches. A gold-beater's *mould* contains from 900 to 950 of these squares, and to furnish this nearly 400 oxen are required. Besides its application in gold-beating, this fine membrane is used in the dressing of slight wounds.

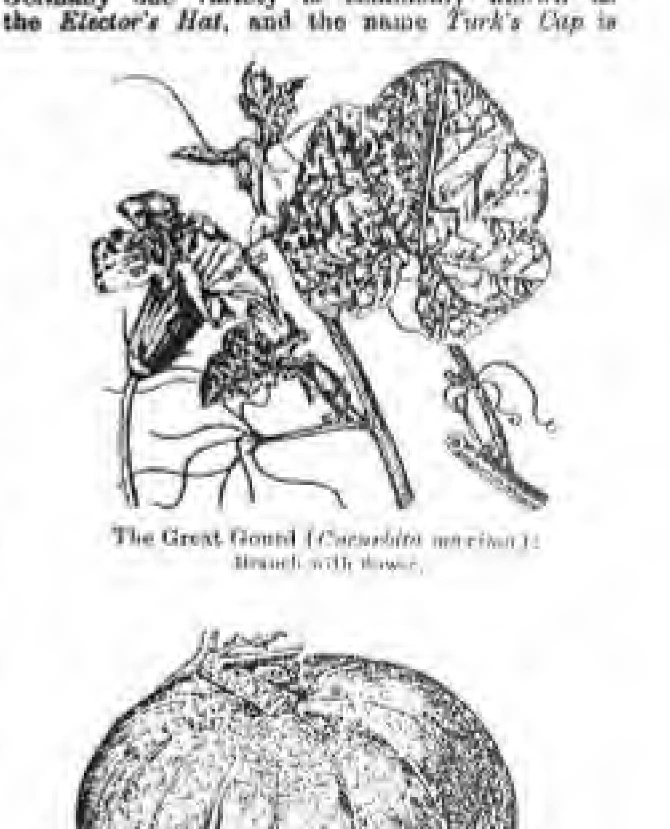
Gold-beating is a very ancient art, having been practised from a remote period among oriental nations. Gilding with leaf-gold is found on the coffins of Egyptian mummies, on some Greek pottery vases of as early a date as the 4th or 5th century B.C., and on portions of the palaces of ancient Rome. Beckmann states that the German monk Theophilus, who appears to have lived at least as early as the 12th century, describes the process nearly as it is at present, the gold having been beaten between parchment, which is practically the same as the modern method. Formerly the gold-beater's art was largely practised in Florence, but in that city the production of fine gold-leaf has greatly diminished during the latter half of the 19th century through French and German competition, the latter country especially now making large quantities of an inferior gold-leaf. Gold-beating is practised in most of the large towns of the United Kingdom, but London is its chief centre.

According to the shade of colour required gold is alloyed for beating either with silver or copper or with both. The proportion of copper rarely exceeds one-twentieth part that of the gold, but the quantity of silver in the alloy is sometimes much larger. The ingot being prepared, it is rolled out into a ribbon 1½ inches wide, a 10-feet length of which weighs an ounce. This length of ribbon is then annealed and cut into about 75 pieces of equal weight. Formerly these were placed between leaves of vellum, but a tough kind of paper is now used with a leaf of vellum at intervals through the packet, which is from 3½ to 4 inches square. The pile of bits of gold ribbon thus interleaved is called a 'cutch,' and this, having been placed upon a thick block of marble about 9 inches square, resting on a strong bench, is beaten with a hammer weighing from 15 to 17 lb., till the pieces of gold extend to the size of the squares of the paper. The hammer rebounds by the elasticity of the vellum, which saves or at least lessens the labour of lifting it. Each square of gold in the cutch is now taken out, cut into four pieces, and placed between leaves of Gold-beater's Skin (q.v.). This packet, termed a 'shoder,' is beaten with a 9-lb. hammer for about two hours, or six times as long as in the first or cutch beating. For the final beating the gold leaves from the shoder are again divided into four, and each piece placed between leaves of fine gold-beater's skin, about 950 of which form a packet termed a 'mould.' After four hours' beating with a 7-lb. hammer the gold-leaf in the mould is of the thickness usually sold, which averages the 282,000th part of an inch. Each skin of the mould is rubbed over with calcined gypsum to prevent the gold adhering to it. One grain of gold in the form of gold-leaf of the ordinary thickness used in gilding measures about 56 square inches, but it can be beaten out to the extent of 75 square inches. A grain of silver can be beaten out to a still greater extent, but the leaf would really be thicker, since this metal has not nearly the density of gold.

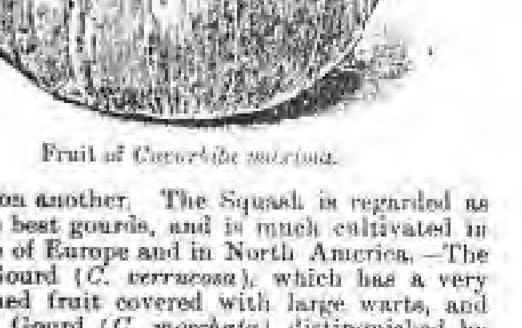
An alloy consisting of 37 grains of gold, 2 of silver, and 1 of copper makes a leaf with a deep yellow colour. A compound containing 4 grains of gold to 1 of silver gives a pale-yellow leaf, but as the proportion of silver is lessened it becomes deeper in the yellow. Seen by transmitted light gold-leaf when only slightly alloyed appears green, but if it contains a large proportion of silver its colour is violet. For external gilding, leaf made from pure gold is the best, as it does not tarnish by atmospheric influences; but it is not so convenient for ordinary purposes.

Gonorrhea (Gr. *gonos*, 'progeny or seed,' and *rheō*, 'I flow'), a name originally applied almost indiscriminately to all discharges from the genital passages in both sexes, but especially in the male. In the course of usage the term has been almost entirely restricted to the designation of one particular kind of discharge, which, from its connection with a contagious poison, was originally called, in strict nosological language, *G. virulenta*. This form of the disease is usually caused by the direct communication of sound persons with those already affected; and accordingly gonorrhea is one of the numerous penalties attending an indiscriminate and impure intercourse of the sexes (see SYPHILIS). Gonorrhea is a very acute and painful form of disease; it is liable, also, to leave its traces in the more chronic form of gleet, which may last for a considerable time. Often, moreover, it leaves some of the parts affected permanently damaged, and stricture, sterility, &c. may result. The only constitutional effect of any importance is a very intractable inflammation of joints, closely resembling rheumatic fever, which occasionally follows it. The name gonorrhea was formed on the erroneous supposition that the discharge consists of the spermatic fluid, whereas, the disease being an inflammation of the mucous membrane of some part of the generative organs, the discharge is the muco-purulent or purulent discharge from the diseased surface. Hence the name *Blennorrhagia* has been proposed for the ailment. The disease may reach its height in a period of from one to three weeks; it then usually subsides, and the various symptoms abate in severity. For gonorrheal ophthalmia, see, under EYE, *Purulent Conjunctivitis*, vol. iv. p. 514. Victims of gonorrhea and the allied disorders should consult none but medical men of high standing and undoubted character.

Gourd (*Cucurbita*), a genus of plants of the natural order Cucurbitaceæ, nearly allied to the cucumber, having male and female flowers on the same plant, the flowers large and yellow. The species are annual plants of very rapid growth, their leaves and stems rough, their leaves broad and lobed, their stems often very long and trailing; they are natives of warm climates, although the native region of the kinds chiefly cultivated is very uncertain, and they have probably been greatly modified by long cultivation, so that perhaps all of them may be forms of one original species, a native of some of the warmer parts of Asia. The Common Gourd or Pumpkin, *Citrouille* of the French (*C. pepo*), with smooth globose or pear-shaped fruit, varying from the size of a large apple to 50 or 100 lb. in weight, is much cultivated both in gardens and fields in almost all parts of the world of which the climate is warm enough for it; and the fruit is not only a very important article of human food, but is also used along with the superabundant shoots for feeding cattle. In many countries pumpkins are a principal part of the ordinary food of the poorer classes, and are much used even by the wealthy; they are not eaten raw, but dressed in a great variety of ways—as in pies, with sugar, spice, &c., or sliced and fried with oil or butter, or made into soups, &c. Pumpkins are much cultivated in North America. In England they are also cultivated, but not to a great extent, and never as food for cattle.—The Vegetable Marrow (*C. ovifera* or *C. succada*) appears to be a mere variety of the pumpkin. It is now more generally cultivated in Britain than any other kind of gourd, being one of the most hardy, and its fruit of excellent quality and useful for culinary purposes at almost every stage of its growth. When full grown the fruit is elliptic, very smooth, generally about 9 inches long and 4 inches in diameter; but there are many varieties distinguished by the form of the fruit and by the delicacy of the texture and flavour of the flesh.—One of the most valuable gourds for culinary purposes is the Great Gourd (*C. maxima*), of which the Spanish Gourd is a green-fruited variety; and the Great Yellow Gourd, the largest of all, has yellow fruit, with firm flesh of a deep yellow colour. It is sometimes fully 200 lb. in weight and 8 feet in circumference. The form of the fruit is a somewhat flattened globe; when boiled it is a very pleasant and wholesome article of food. It is much cultivated in the south of Europe. The French call it *Potiron*, and use it largely in soups.—The Squash (*C. melopepo*) differs from all these in generally forming a bush, instead of sending out long trailing shoots; also in the extremely flattened fruit, the outline of which is generally irregular, and its whole form often so like some kinds of cap that in Germany one variety is commonly known as the ***Elector's Hat***, and the name *Turk's Cap* is



The Great Gourd (*Cucurbita maxima*): Branch with flower.



Fruit of *Cucurbita maxima*.

bestowed on another. The Squash is regarded as one of the best gourds, and is much cultivated in some parts of Europe and in North America.—The Warted Gourd (*C. verrucosa*), which has a very hard-skinned fruit covered with large warts, and the Musk Gourd (*C. moschata*), distinguished by its musky smell, are less hardy than the kinds already named; as is also the Orange Gourd (*C.*

aurantia), sometimes cultivated on account of its beautiful orange-like fruit, which, however, although sometimes edible and wholesome, is not unfrequently very unfit for use, on account of colocynth developed in it. This is apt to be the case in some degree with other gourds also, but the bitter taste at once reveals the danger. The same remark is applicable to the young shoots and leaves, which, when perfectly free from bitterness, are an excellent substitute for spinach. In Scotland even the most hardy gourds are generally reared on a hotbed and planted out. In England it has been suggested that railway-banks might be made productive of a great quantity of human food by planting them with gourds. Ripe gourds may be kept for a long time in a cool well-ventilated place, nor are they injured by cutting off portions for use as required. The name gourd is often extended to many other Cucurbitaceæ. See BOTTLE-GOURD.

Grafting, a mode of propagation applicable to all kinds of trees and shrubs, and even herbaceous plants whose tissues are firm. The operation consists in the inserting of a branch or bud (*scion*) of one tree into some part of another tree (*stock*), so as to bring about a union of the two. The practice of grafting is doubtless one of great antiquity, and its origin may in all probability be traced to a natural process which is of frequent occurrence. It has been observed that, when two branches of a tree or branches and even the stems of kindred trees growing closely together overlap and touch each other, the bark becomes wounded or abraded, and the returning juices exuding from the ruptured vessels in the *Alburnum* (q.v.) produce granulations by which a perfect incorporation of structure is effected, and the parts become one. The object of grafting is, first, to perpetuate and increase the stock of varieties and sub-varieties of fruit-trees, the innate qualities of which cannot be transmitted with certainty to their progeny by seeds, and which would be more slowly and less surely multiplied by any other artificial mode of propagation; secondly, to increase and accelerate the fruitfulness of fruit-trees—for, the elaborated sap being impeded in its descent at the junction of the scion with the stock, the process of maturation is thereby promoted, and fertility more largely and quickly induced. Old and unfruitful trees, whose stems and roots are vigorous and healthy, may be rendered fruitful in the course of two or three years by having their tops cut back and re-grafted with scions from a fruitful and healthy tree. Grafting is also employed for the purpose of dwarfing fruit-trees, while at the same time abnormally increasing their fruitfulness. This is attained partly by the selection of a stock which exerts a restrictive influence on the scion, and by double grafting—i.e. grafting twice or oftener at will. Very young trees are thus rendered prodigiously fruitful, and are in demand for the purpose of pot culture and planting in orchard-houses. Trees damaged by wind or otherwise have their injuries repaired by grafting, and those that are unequally balanced may be brought to perfect symmetry by the judicious insertion of scions in the ill-furnished parts.

In grafting it is particularly to be attended to that the *alburnum* of the scion is brought into contact with that of the stock. The hard wood of the one never unites with that of the other, remaining separate and marking the place of the operation even in the oldest trees. For scions or grafts, pieces of about six to eight inches long are generally taken from the shoots of the previous summer, with several buds; but portions of shoots of two years old are sometimes successfully employed. The time for grafting is in spring, as soon as the sap begins to appear. The scion should, if possible, be taken from a healthy and fruitful tree, but scions from the extremities of lateral branches are more likely to become speedily fruitful than those from the uppermost branches, where growth is most vigorous. The scion should be kept for a few days before grafting, so that the stock may rather exceed it, not only in vigour, but in the progress of its spring growth; and for this purpose it may be placed in the ground, in a rather dry soil, sheltered from the direct rays of the sun. Scions may be kept for some time, and easily carried to a distance, by sticking their lower end into a potato or moist moss or clay. The end should always be freshly cut off when the scion is to be used. There are various modes of grafting.

Fig. 1.—Cleft-grafting.

Cleft-grafting (fig. 1) is very commonly practised when the stock is very considerably thicker than the scion. The stock, being cut over, is cleft down, and the graft, cut into the shape of a wedge at its lower end by a sharp thin knife, is inserted into the cleft. This mode of grafting is particularly applicable to branches of large trees, when the introduction of a new variety of fruit or increased fruitfulness is sought.—*Crown-grafting* is used for still thicker stocks, which are cut across, and then cleft down by two clefts crossing one another at right angles, two scions being inserted close to the bark in each cleft; or no cleft at all is made, and any desired number of scions obliquely cut away on one side are simply inserted between the bark and wood of the stock, the operation in this case being deferred till the bark readily parts from the wood. In this kind of grafting a longitudinal slit in the bark of the stock, opposite to each graft, is advantageous. — *Tongue-grafting* (fig. 2) is the mode most commonly practised for young trees in nurseries. For this it is necessary that the stock and the scion should be of not very different thickness.

Fig. 2.
a, tongue-grafting; *b*, do. with ligature applied; *c*, do. with clay applied.

A slit or a very narrow angular incision is made in the centre of the stock downwards, and a similar one in the scion upwards, both having been first cut obliquely at corresponding angles; and, the tongue thus made in the scion being inserted into the incision in the stock, they are fastened very closely and thoroughly together. In *saddle-grafting* the end of the stock is cut into the form of a wedge, and the scion is affixed to it, the base of the scion having been cut or slit up for the purpose.—*Shoulder-grafting*, used chiefly for ornamental trees, is performed by cutting obliquely, and then cutting across a small part at top of the stock, so as to form a shoulder, the scion being cut to fit it.—*Peg-grafting*, not now much in use, is accomplished by making the end of the scion into a peg, and boring the top of the stock to receive it.

Whichever of these modes of grafting is adopted the graft must be fastened in its place by tying, for which purpose a strand of bast-matting is commonly used. The access of air is further prevented by means of clay, which has been worked up with a little chopped hay, horse or cow dung, and water, and which is applied to the place of junction so as to form a ball, tapering both upwards and downwards. In France a composition of 28 parts black pitch, 28 Burgundy pitch, 16 yellow wax, 14 tallow, and 14 sifted ashes is generally used instead of clay. The progress of the buds shows the union of the graft and stock, but it is not generally safe to remove the clay in less than three months; and the ligatures, although then loosened, are allowed to remain for some time longer. From some kinds of fruit-trees fruit is often obtained in the second year after grafting.

Budding (q.v.) is in principle the same as grafting; and *flute-grafting* is a kind of budding in which a ring of bark with one or more buds is used instead of a single bud, and, a stock of similar thickness having been cut over, a corresponding ring of bark is removed, and the foreign one substituted. This is commonly performed in spring, when the bark parts readily, and is one of the surest modes of grafting.—*Inarching* or *grafting by approach*, in which the scion is not cut off from its parent stem until it is united to the new stock, is practised chiefly in the case of some valuable shrubs kept in pots, in which success by the ordinary methods is very doubtful.

An effect is produced by the stock on the scion which it nourishes analogous to that of a change of soil; much of the vigour of a strong healthy stock is also communicated to a scion taken even from an aged tree. There is, moreover, in some degree, an influence of the elaborated sap descending from the scion on the stock which supports it. An important part of the practical skill of the gardener or nurseryman consists in the selection of the proper kinds of stocks for different species and varieties of fruit-trees. The stock and scion, however, must not be of species extremely dissimilar. No credit is due to the statements of ancient authors about vines grafted on fig-trees, apples on planes, &c., the semblance of which can only have been brought about by some delusive artifice; for all attempts at grafting fail except among plants of the same genus, or at least of the same natural family.

Herbaceous plants with firm stems, as dahlias, are sometimes grafted. Some kinds of plants, of small size, in pots, are placed in moist hothouses or hotbeds, under bell-glasses, whilst the junction of the scion and stock is going on, which in these circumstances takes place very surely and very expeditiously. But an accumulation of too much moisture under the bell-glass must be guarded against.

Gramme is the standard unit of French measures of weight, and is the weight of a cubic centimètre of distilled water at 0° Centigrade (corresponding to 32° F.); the other weights have received names corresponding to the number of grammes they contain, or the number of times they are contained in a gramme (see DECIMAL SYSTEM, METRIC SYSTEM). A gramme = 15·43248 grains troy, from which the equivalents in English measure for the other weights can easily be found; thus:

		Grains Troy.		Lb. Avoirdupois.		
Centigramme	=	·1543234	=	·0000220462		
Decigramme	=	1·543234	=	·000220462		
Gramme	=	15·43234	=	·00220462		
Decagramme	=	154·3234	=	·0220462		
Hectogramme	=	1543·234	=	·220462		
Kilogramme	=	15432·34	=	2·20462		
Myriagramme	=	154323·4	=	22·0462	=	·19684 cwt.
Quintal (q.v.)	=	1543234	=	220·462	=	1·9684 „

GRAMME-ATOM.—A quantity of an elementary substance, such that the number of grammes-weight is the same as the atomic number of the element—e.g. 12 grammes of carbon (C = 12).

GRAMME-EQUIVALENT.—A number of grammes-weight of a substance, elementary or compound, equal numerically to the quantity of that substance which is chemically equivalent to unit weight of hydrogen—e.g. 8 grammes of oxygen, 9 grammes of water.

GRAMME-MOLECULE.—A quantity of a substance, elementary or compound, such that the number of grammes and the molecular weight are numerically the same—e.g. 32 grammes of oxygen ($O_2 = 32$), 18 grammes of water ($H_2O = 18$).

Grape-shot.

Grape-shot, called also *tier-shot*, consists of small iron balls piled round an iron pin, holding together a series of parallel iron plates of the same diameter as the gun from which they are to be fired, between which are the shot, kept in their places by holes in the plates. On being discharged they spread over a wide area. In another pattern called *quilted* grape the shot are held together on the central pin by canvas instead of iron plates. Both have now almost ceased to be used, their place being taken by *case-shot*, sometimes called *canister*.

Grass-oil, a name under which several volatile oils derived from widely different plants are grouped. The grass-oil obtained by distillation from the leaves of *Andropogon warancusa* is used for rheumatism, and has the same stimulant effect as cajeput oil. Ginger-grass Oil is obtained from *A. nardus*, a native of India, and other species of the same genus. Geranium Oil, derived from *Pelargonium radula*, is so like ginger-grass oil in its properties that they are used for the same purposes, and are bought and sold under either name, mainly as an adulterant of Oil of Rose. Turkish Grass-oil is obtained from *A. pachnodes*, indigenous to India, Persia, and Arabia. Lemon-grass Oil, or Citronella Oil, is derived by distillation from *A. schœnanthus*, indigenous to India and cultivated in Ceylon. It has an odour resembling oil of citron, and is largely used for scenting soap. Cyperus-grass Oil is extracted from the tubers of *Cyperus esculentus*, indigenous to southern Europe, and is used both as a table oil and in the manufacture of soap.

Greek-fire, a composition supposed to have been of pounded resin or bitumen, sulphur, naphthe (the principal ingredient), and probably nitre, with which, from about 673 A.D. onwards, the Greeks of the Byzantine empire were wont to defend themselves against their Saracen adversaries. The accounts of its effects are so mingled with obvious fable that it is difficult to arrive at any just conclusion as to its power; but the mixture appears to have been highly inflammable, and to have been difficult to extinguish; though the actual destruction caused by it was hardly proportionate to the terror it created. It was poured out, burning, from ladles on besiegers, projected out of tubes to a distance, or shot from balistæ, burning on tow tied to arrows. The invention of this material has usually been ascribed to Callinicus of Heliopolis, and to the year 668 A.D. At Constantinople the process of making Greek-fire was kept a profound secret for several centuries. The knowledge, however, of its composition gradually spread; and the use of it spread to the West. Subsisting for some time concurrently with gunpowder, it gradually died out before the advances of that still more effective competitor. Combustibles with a similar aim were used at the siege of Charleston in 1863, composed of sulphur, nitre, and lampblack; and naphtha in shells was also tried. The petroleum bombs of the Paris Commune of 1871 corresponded more nearly to Greek-fire than does gunpowder.

Green Pigments. These are numerous and some are very important. Several of them are mechanical mixtures of blue and yellow; a larger number are chemical compounds which are naturally green; but of either kind only a few are extensively used. All those which are serviceable or have any special interest are noticed in what follows.

Sap green is the only one of vegetable origin that need be mentioned. It is prepared from the gummy juice of the berries of a species of buckthorn (*Rhamnus catharticus*), and is a fine transparent yellowish-green. It is unfortunately fugitive, but is occasionally employed in water-colour painting.

Terra verte is a kind of ochre. This pigment is much used by artists for painting in oil, being one of the most permanent greens. It has not much body, but can be mixed with other colours without injurious results.

Oxide of chromium, like the last, is found native, but for use as a colour it is always artificially prepared. It is a sober, permanent green much liked by some landscape-painters. *Viridian* and *Veronese green* are also oxides of chromium, but the latter is often adulterated with arsenic.

Emerald green (cupric aceto-arsenite).—This very bright (but poisonous) green, also called *Schweinfurt green*, is only employed to a limited extent by artists and decorators, but is used for other purposes. It is fairly permanent.

Scheele's green (cupric arsenite) is another bright green, although not so vivid in colour as the last, which it resembles in stability and in other properties. This is a dangerous pigment, and is unfortunately a good deal employed for colouring paper-hangings, artificial leaves, and toys.

Brunswick Green.—Several distinct pigments are known by this name. One of the kinds employed by the house-painter is a basic carbonate of copper, mixed with gypsum or other bodies. It is fairly permanent. Mountain green, mineral green, and malachite green are also carbonates of copper. In chemical books Brunswick green is usually said to be the oxychloride of copper. Chrome green, noticed below, is likewise called Brunswick green.

Rinman's green, known also as zinc green and cobalt green, consists of 88 per cent. of oxide of zinc and 12 per cent. of protoxide of cobalt. This colour is permanent, and is not affected by strong heat.

Chrome green is a mixture of chromate of lead and Prussian blue. It is a bright, strong colour, and is suitable for ordinary mechanical painting. It is, however, not permanent; a more durable green, but one of less power, being formed with French ultramarine and chrome yellow.

Hooker's green is a mixture of Prussian blue and gamboge, and possesses some permanence as a water-colour. *Prussian green* is formed in the same way, but contains more blue.

Greens which are compounds of copper are all more or less poisonous even when they do not also contain arsenic.

Artists generally prefer to make up the shade of green they require by mixing blue and yellow pigments for bright shades, and blue and brown colours for dull shades. As a rule the green portions of pictures have stood the effects of time worse than other colours.

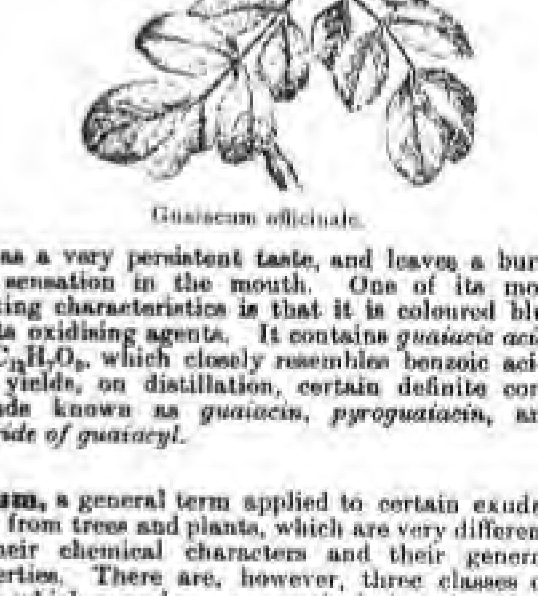
For the materials used in dyeing textile fabrics green, see DYEING.

Ground-nut, GROUND-BEAN, or PEA-NUT, the fruit of *Arachis hypogæa*, an annual plant belonging to the natural order Leguminosæ, extensively cultivated in southern North America, but supposed to be a native of Africa. The name *Arachis*, *Aracos*, or *Aracidna*, was given by Pliny to a plant which was stemless and leafless, being all root. Modern botanists have given the name to a species which ripens its fruit underground. The pods, though first formed in the air, are as they increase in size forced into the earth by a natural motion of their stalks, and there come to maturity 3 or 4 inches under the surface, hence the popular name Ground- or Earth-nut. In the southern states of North America the seeds, or nuts, as they are called, are roasted and used as chocolate. When fresh they have a sweet taste resembling almonds. They are a favourite article of food with the negroes. A fixed very sweet oil is extracted from the seeds, which is considered by some equal to olive-oil, and it does not become rancid, rather improving with age. Ground-nuts are to be met with occasionally in fruiterers' shops in Britain, and some attempt has been made to cultivate the plant around Paris; but requiring as it does to be reared in hot-beds, expense and trouble have circumscribed its adoption as a commercial production there. It is, however, cultivated in some of the warmer countries of the south of Europe.—The roots of *Bunium bulbocastanum* and *B. flexuosum* are also known as ground-nuts or Earth-nuts (q.v.).

Ground-nut (*Arachis hypogæa*).

Gruel is a mild, nutritious, easily-digested article of food. To prepare it, put a teacupful of oatmeal into a pint of water; after standing twenty minutes pour off the water, rejecting the coarse parts of the meal; boil the water twenty minutes. It may be flavoured according to taste; butter should not be added if the gruel is meant for invalids. Gruel is more nourishing than preparations from arrowroot, sago, tapioca, and other starchy substances.

Guaiacum, a genus of trees of the natural order Zygophyllaceæ, natives of the tropical parts of America. The flowers have a 5-partite calyx, five petals, ten stamens, and a tapering style; the fruit is a capsule, 5-angled and 5-celled, or the cells by abortion fewer, one seed in each cell. The trees of this genus are remarkable for the hardness and heaviness of their wood, known variously as *Lignum Vitæ*, as *Guaiacum-wood*, and as *Brazil-wood*; as well as for their peculiar resinous product, *Guaiacum*, often but incorrectly called a gum. The species to which the commercial Lignum Vitæ and Guaiacum are commonly referred is *G. officinale*, a native of some of the West India islands, and of some of the continental parts of America; a tree 30 or 40 feet high, leaves abruptly pinnate, with two or three pairs of ovate, obtuse, and perfectly smooth leaflets, pale blue flowers in small clusters, which are succeeded by compressed roundish berries, a furrowed bark, and generally a crooked stem and knotty branches. It seems probable, however, that other species, as well as this, supply part of the guaiacum-wood and resin of commerce. At present they are obtained chiefly from Cuba, Jamaica, and St Domingo. The wood is imported in billets about 3 feet long and 1 foot in diameter, of a greenish-brown colour. This is the colour of the heart-wood; the sap-wood is pale yellow. Guaiacum-wood is remarkable for the direction of its fibres, each layer of which crosses the preceding diagonally; annual rings are scarcely to be observed, and the pith is extremely small. It sinks in water. It is much valued, and used for many purposes, chiefly by turners; ships' blocks, rulers, pesties, and bowls (see BOWLS) are among the articles most commonly made of it. When rubbed or heated, it emits a faint disagreeable aromatic smell; its taste is also pungent and aromatic. Shavings and raspings of the wood are bought by apothecaries for medicinal use. The bark is also used in medicine on the continent of Europe, although not in Britain. The virtues of both wood and bark depend chiefly on the resin which they contain, and which is itself used in powder, pill, and tincture. It is an acrid stimulant, and has been employed with advantage in chronic rheumatism, in chronic skin diseases, in certain cases of scanty and painful menstruation (and hence it is occasionally an effectual remedy in cases of sterility), and in chronic catarrh. It has also been highly praised as a preventive of gout. The resin is an ingredient of the well-known *Plummer's Pills*. In the 16th and 17th centuries Guaiacum was the remedy most in repute for syphilis. It is used in testing Blood-stains (q.v.). The resin sometimes flows spontaneously from the stem of the Guaiacum tree; it is sometimes obtained artificially. It is of a greenish-brown colour, and has a brilliant resinous fracture.



Guaiacum officinale.

It has a very persistent taste, and leaves a burning sensation in the mouth. One of its most striking characteristics is that it is coloured blue by its oxidising agents. It contains *guaiacic acid*, $HOC_{12}H_7O_2$, which closely resembles benzoic acid, and yields, on distillation, certain definite compounds known as *guaiacin*, *pyroguaiacin*, and *hydride of guaiacyl*.

Gum, a general term applied to certain exudations from trees and plants, which are very different in their chemical characters and their general properties. There are, however, three classes of gums which may be more particularly referred to—viz. those containing arabin, those containing bassorin, and gum-resins.

(1) *Gums containing arabin* are best represented by gum-arabic, the ordinary gum of the shops. This substance is found as an exudation on the bark of the *Acacia Senegal*, a tree of some 20 feet in height, growing abundantly in western Africa. According to the care taken in collecting it, it ranges from the pure white or colourless gum of Kordofan to the dark-reddish varieties imported from Senegal. Chemically these are absolutely identical, and therefore a single description will suffice. It occurs in irregular lumps, somewhat spherical or vermicular (as in Gum-Senegal). It is brittle, and shows a glassy fracture. It dissolves readily in water, forming a clear, viscid, adhesive solution; but it is insoluble in strong alcohol, glycerine, ether, oils, or chloroform. The addition of alcohol to a watery solution throws down a precipitate of arabin, if a few drops of hydrochloric acid have previously been added.

Medicinally it has very slight remedial powers, but it is largely used in prescriptions for the purpose of suspending insoluble substances in mixtures. The finer varieties, owing to their cost, are rarely found outside the druggist's shop; but in the manufacture of confections and in the arts large quantities of the cheaper kinds are employed. These are known under different names, indicating the district from which they are imported. The chief are: Senegal gum, found in large firm reddish masses; Suakin gum or Talka gum, forming dull opaque-looking tears, colourless or brownish; and Morocco or Barbary gum. Cape gum is derived from the *Acacia horrida*, a native of Cape Colony, while Wattle gum is a very adhesive variety obtained from Australia. East Indian gum is an African product, being simply imported into Bombay from the Red Sea.

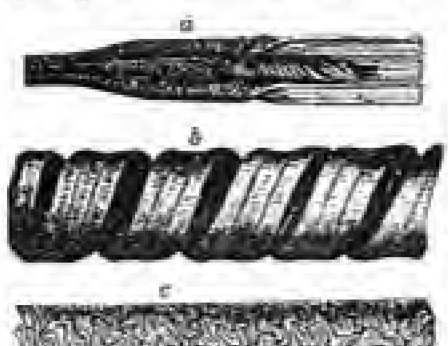
(2) *Gums containing Bassorin.*—The chief of these, Tragacanth, is obtained from various species of Astragalus, low spiny bushes, natives of Asia Minor and Persia. When the stem of one of these plants is cut transversely it will be found that the space usually occupied by the pith has the appearance of a translucent gummy mass, which the microscope shows to possess the structure of an ordinary pith. If incisions are made in the bark, this semi-solid exudes under pressure, and, according to the nature of the incision forms flattened wing-like masses, nodules or worm-like pieces. The finest variety is known as Flake-Tragacanth, consisting of flakes 1 to 3 inches long by 1 inch in breadth. The surface is marked by wavy lines and the flakes are much contorted. Tragacanth is translucent, white and without lustre, somewhat flexible, and not brittle, and with little taste or smell. When placed in water it swells, absorbing fifty times its weight of that liquid, and forming a thick mucilage. It has no active medicinal properties; but it is much used for firming pill masses and lozenges. It enters into many emulsions, for instance, that of cod-liver oil, and it is sometimes employed as a stiffener for the hair. It is used as a stiffening material for various textile fabrics, and is much valued for this purpose, where it is not desired to give gloss to the material.

Besides these true gums, there are (3) *the gum-resins*. In general terms these consist of certain resins soluble in alcohol, and of the true gum, so that it requires both water and alcohol to dissolve them entirely. They are chiefly used in medicine and perfumery, and may be said to form a connecting link between the true gums and the true resins, commercially speaking. The principal are: (1) Gum-Ammoniacum (see AMMONIACUM), (2) Gum-Asafœtida (see ASAFŒTIDA), (3) Gum-Benzoin (see BENZOIN), (4) Gum-Galbanum (see GALBANUM), (5) Gum-Gamboge (see GAMBOGE), (6) Gum-Myrrh (see MYRRH), (7) Gum-Scammony (see SCAMMONY). There are many other gums known; but these are the ones most used in the arts and medicine. Many also of the true resins, as copal, anime, &c., are called gums, but they are strictly resins. See RESINS.

Gum-substitutes are manufactured from various forms of starch, either by baking, roasting or chemical treatment, so as to convert the starch into Dextrine (q.v.). They are made on a very extensive scale, and are largely employed in dressing calicoes and other fabrics, also as a substitute for the more expensive gums in gumming-paper, as in the case of postage-stamps and labels, which are made adhesive by dextrine. For this and some other purposes, the *gum-substitutes* are superior to the real gums, as they are easily dissolved, and can be spread more equally over a smooth surface.

Gun. The term gun formerly comprised many varieties of the weapons now more correctly termed Firearms (q.v.), and is still applied in a general sense to Cannon (q.v.) and large ordnance, also to quick-firing or Machine Guns (q.v.); but it is now more specially held to signify the sporting gun as distinguished from the military Rifle (q.v.). The modern shot-gun is invariably breech-loading, and usually upon the 'drop-down' principle (see BREECH-LOADING). The manufacture of shot-guns is an important British industry, and one of the processes of manufacture—barrel-welding—is sufficiently interesting to warrant descriptive details. The other processes, some eighteen or twenty in number, call only for the skill of the trained workman.

Shot-gun barrels are generally hand-forged from a rod of special material which is usually composed of iron of two distinct varieties, or of iron and steel. It is necessary that one of the metals be softer than the other; and the greater the proportion of the harder metal, and the harder the quality of the softer metal, the better will be the quality of the welded barrel. Some varieties of



a, gun-barrel iron, twisted and laid into a riband; b, portion of gun-barrel coil; c, portion of silver-steel Damascus barrel.

gun-iron contain 70 per cent. of steel; in others a good quality and an inferior quality of iron are used together, and no steel enters into the composition. The rod of gun-iron is built up of alternate layers of the hard and soft metals, and in the manufacture of a Damascus barrel this rod must be twisted upon itself before it is welded side by side to one or more rods, or welded into a barrel. These twisted rods are drawn out between rolls into a flattened rod or 'riband' of metal, the riband being composed of one, two, three, or more twisted rods according to the quality of the barrel or the *fineness* of figure desired. The Belgian welders are more expert than the British in making the finest figured barrels, putting as many as six differently twisted rods together to form a single riband; but Belgian barrels are not so hard as the English, and are generally considered to be inferior to the best Birmingham hand-welded barrels. The welder, having prepared his iron and received it from the mill rolled down to the proper size, proceeds to form the barrel by twisting the riband upon a mandril, just as one would cover a whip-stock with a narrow strip of leather. This coil has then to be heated, a few inches at a time, and the edges welded to each other, the result being a tube four times heavier than it will weigh when finished by boring, grinding, and filing, which are the next three processes through which the barrel must pass. In double shot-guns the two tubes to form the barrels are brazed together for a few inches at the breech end, and soldered to each other and to the two ribs and 'packing' which unite them throughout their entire length. The breech actions are fitted to the barrels, the lock-work and bolting-mechanism adjusted, and the gun is ready for the stocker; he roughly fashions the piece of walnut to which the ironwork is secured by the 'screwer,' who passes the gun on to the 'finisher' to prepare for its final embellishments, in which are comprised the processes of polishing, engraving, hardening, blueing, and tempering. The barrels when finely polished are treated with acid, which rusts the surface of the metals of which they are composed, and eating more readily into the softer metal turns it a darker colour. This process, termed 'browning,' occupies several days, and when successful shows clearly the damascening or curls of fibre obtained by twisting the gun-iron rods in the earliest stage. A barrel not showing such curls would be termed a 'scelp' barrel if it were a twisted welded barrel, but if of one uniform colour, unbroken by regular markings, it would probably be composed of plain iron or steel only.

The superiority of the Damascus barrel to one of best modern steel remains a vexed question. The evidence adduced on behalf of the Damascus is sufficient to prove its superiority over certain qualities of steel, but it is not overwhelming; and it is now generally admitted that steel can be obtained of sufficiently good quality and possessing sufficient strength to withstand any normal strain to which as a shot-gun barrel it may be subjected. The advocates of the welded barrel contend that flaws, which cannot be detected by the eye or by the most searching test, occasionally exist in steel, making it unreliable for use as a gun-barrel. Sir Joseph Whitworth's fluid compressed steel has been used very successfully as a material for shot-gun barrels, but the immunity from flaws which barrels of this steel enjoy is said to result from the careful testing and examination of each individual tube rather than from absolute perfection in the metal itself. The complete and almost perfect heterogeneity of the material of the Damascus barrel produces a homogeneous whole, which, when soundly welded, has no weak spot, and will neither split longitudinally nor break off short as steel barrels have done, but when burst is pulled, as it were, from shred to shred, exhibiting great tenacity in every direction. The steel barrel here referred to is that drilled from a solid rod of best mild steel. Steel barrels drawn from blanks in the same manner as ordinary tubes are inferior to the drilled barrel. Still less reliable are the lap-welded steel barrels in which the two edges of a strip of metal are brought together and welded as it passes at welding heat between the rolls. Cold drawn steel barrels were at one time manufactured, but proved too expensive, and twisted steel barrels are not yet a commercial success. The standard size of the modern shot-gun is 12 bore—i.e. twelve spherical leaden bullets of the same diameter as the interior of the barrel will weigh 1 lb. avoir.; formerly 16 and 20 bores were much in vogue, and 16 bores are still very common in Germany; 10 bores are much used in North America; 8 and 4 bores are used only for wild-fowling; and *punt-guns*, guns of from 1-inch to 3-inch bore fitted into shooting punts, are employed for firing from ½ lb. to 4 lb. of shot at a time into flocks of sea-fowl on the coast or in tidal estuaries.

With the exception of the punt-guns, which require special mechanism, guns of all bores are made upon the same principle of breech-loading, and nearly all are more or less choked—i.e. the diameter of the barrel is suddenly lessened near the muzzle, forming a cone which causes the pellets of the charge to fly from the gun more compactly and at an increased velocity. Such is the perfection to which the boring of shot-guns has been brought that a 7-lb. gun may now be expected to send on an average 220 pellets of a charge containing 305 pellets into a circle 30 inches in diameter (or 60 into a 10-inch square) at 40 yards distance, the pellets having an average velocity at the muzzle of 840 feet per second, and a striking force at impact (40 yards) of 1·90 oz.

Shot-guns are now built very much lighter than when breech-loaders first came into general use (1865); shorter barrels are used without loss of shooting power or appreciable increase in the volume of the recoil. Smokeless explosives are in general use all the world over for shot-guns, and the results of the slightest variation in the charge or quality of the powder, or in the size and quantity of the shot, can be ascertained with the greatest scientific accuracy, by means of special instruments found in all leading gun-manufactories. Shot-gun manufacture is a mechanical science as well as a handicraft, and the finest productions of the most renowned gun-makers will always command £50 or even higher prices. Cheap ill-made, ill-fitted, ill-regulated guns, shaped by machinery, or still more roughly by hand labour, constitute the shot-gun of commerce, and their value fluctuates with the price of material. The shot-gun of the best class is now so highly perfected that a new departure, whether towards the development of the killing powers of the weapon or elaboration of its mechanism, is undesirable, and, until some radical change in the composition of explosives, or the method of using shot-guns, takes place, no noteworthy improvement upon the existing type of gun can be expected.

Gun-cotton. There are a very large number of explosive nitro-compounds which may be divided into two main classes—viz. (1) Those containing Nitro-glycerine (q.v.), in which is included the great dynamite class, and (2) those not containing nitro-glycerine. Gun-cotton is an explosive nitro-compound of the latter class, and is by far the most important of the class.

So long ago as 1832 it was discovered by Braconnot that woody fibre and similar substances could be converted into highly combustible bodies by the action of concentrated nitric acid; six years later Pélouze extended this discovery to cotton and other organic substances; he was followed by Dumas, who treated paper in a similar way, and he proposed to make cartridges with paper so treated, the idea being that no residue would be left in the barrel after firing such cartridges. But no practical result followed these discoveries until in 1845 Schönbein, a German chemist, having hit upon the proper mode of treating cotton with nitric and sulphuric acids, announced the discovery of gun-cotton, which he proposed as a substitute for gunpowder. He claimed for it that the advantage it had over gunpowder was that it burned without leaving any residue, and consequently without smoke. He prepared it by immersing carded cotton wool in a mixture of nitric and sulphuric acids, and the equation for its formation may be stated thus:

Cellulose.	Nitric Acid.	Bi-nitrated Cellulose or Gun-cotton.	Water.

$$C_6H_{10}O_5 + 3(H.NO_3) = C_6H_7O_2.3(NO_3) + 3(H_2O).$$

It will be observed that no mention is made of sulphuric acid in this equation, the presence of which is, however, essential in the production of gun-cotton, for although it takes no active chemical part in the action, it absorbs the water which is formed by the chemical transformation, and thus keeps the nitric acid up to its full strength. Schönbein's discovery gave a great impetus to the question, and experiments continued to be made by many eminent chemists in nearly every country in Europe with the idea of utilising the new explosive for military purposes. It was first manufactured in England on a large scale in the year 1847 by Messrs Hall & Son of Faversham; but, in addition to minor accidents, a terrible explosion took place in their works, which created so much distrust that its manufacture in England was discontinued for several years, as the cause of the explosion, with the then imperfect knowledge possessed of the subject, could not be satisfactorily accounted for. The first country to turn Schönbein's discovery to practical account was Austria. General Von Lenk, an Austrian artillery officer, after extensive trials succeeded in greatly improving the method of manufacture, by which means he was enabled to moderate and ensure a uniform rate of combustion of gun-cotton in air; his discovery was considered of so much importance that in the year 1852 several batteries of Austrian artillery were armed with gun-cotton cartridges. But it soon fell into disrepute, not only on account of its unstable nature, but also because it was found that Von Lenk's improvements were of no practical utility when the gun-cotton was confined in the bore of a gun; the great heat generated caused the inflamed gas to penetrate rapidly through the whole cartridge, so that there was little or no retardation in the rate of combustion, and the rapid combustion caused excessive pressure in the bore, besides giving very unequal results when fired.

Since the failure of the Austrian cartridges gun-cotton has not been used as a propelling agent on a large scale. But its utility as a disruptive agent has been enormously increased by the discoveries of Professor Sir Frederick Abel and the late Mr E. O. Brown. Nothing daunted by the failure of the Austrian experiments, nor by the explosion at Messrs Hall's works, Sir Frederick Abel continued his experiments, and he ultimately discovered a method of manufacture whereby not only a complete purification from free acid is assured, but the material is converted into thoroughly compact homogeneous masses. As a result of his experiments the method of manufacture adopted in England may be briefly described as follows: the best white cotton waste alone is employed; this is first thoroughly cleansed from all grease by boiling with alkalies; it is then picked over by hand and all foreign substances removed, after which the fibre is separated and all knots and lumps opened out by passing the cotton waste through a 'teasing' machine; it is then cut into 2-inch lengths, thoroughly dried, and divided into charges weighing $1\frac{1}{4}$ lb. each, which are kept in air-tight tin boxes till ready for dipping. The acids used in the manufacture of gun-cotton are nitric acid having a specific gravity of 1·52 and sulphuric acid of 1·84 sp. gr.; these are mixed in the proportion of one part by weight of nitric acid to three of sulphuric acid, and allowed to cool down in iron tanks. The mixed acid is run off into the dipping pans into which a $1\frac{1}{4}$-lb. charge of cotton is immersed and left in for about five minutes, in which time it will have absorbed about 14 lb. of acid. The charge is now allowed to cool down, after which the waste acid is extracted by means of an 'acid-extractor,' and the charge thoroughly washed to remove all the free acid. It is now pulped and pressed under hydraulic presses to one-third its bulk, and moulded into slabs of various sizes and shapes for storing. The method of manufacture as here described is perfectly safe, as the gun-cotton throughout is in a wet state.

The properties of gun-cotton, as compared with gunpowder, are mainly as follows: (1) It can be ignited at a temperature of about 300°, whereas gunpowder requires a temperature of about 600° to ensure ignition; (2) its combustion leaves no solid residue, and is unattended by smoke; (3) the action of gun-cotton is much more rapid than that of gunpowder, and, as has already been pointed out, it is this rapidity of combustion which renders it unsuitable to be used as a propelling agent in cannon; (4) whereas gunpowder is greatly influenced and injuriously affected by moisture, gun-cotton on the contrary is perfectly uninjured, and may be kept for any length of time in water without change. For military purposes this is a most important consideration. Apart from the question of using gun-cotton as a propelling agent, its value for destructive purposes was incontestable, but it was thought to be necessary, in order to develop its full power, that the charge should be strongly confined. Experiments, however, conducted by Mr E. O. Brown clearly demonstrated the fact that compressed gun-cotton could be fully detonated in a totally unconfined state by fulminate of mercury. This discovery was thought to apply to dry gun-cotton only, but Mr Brown continuing his experiments ascertained that wet compressed gun-cotton could be detonated by using a small primer of the dry material. Still further discoveries were made with regard to the detonation of gun-cotton; it was ascertained that detonation, being established at one end of a continuous row of distinct masses of compressed gun-cotton, travels along the whole length of the row, even if a space of half an inch is left between the discs. These discoveries have raised gun-cotton to the highest rank as a military explosive, as the necessity for storing it in a dry state, which is so highly dangerous, is entirely obviated; it is now always stored in a wet state, the gun-cotton containing about 20 per cent. of water, and is packed in air-tight metal cases, so that the necessity for rewetting seldom occurs; in this condition it can be transported with perfect safety.

The discovery with regard to its detonation when in a wet state has led to this material being used as the charge for torpedoes and submarine mines. The first pattern of Whitehead torpedo was 14 feet long and 16 inches in diameter; the speed of the torpedo was 9 knots for 200 yards, and the charge was 118 lb. of compressed wet gun-cotton. Several subsequent patterns of torpedoes have been introduced, the latest being 14 feet long and 14 inches in diameter, and by reducing the charge of gun-cotton to 80 lb. the high speed of 27 knots for 600 yards has been attained. The immense importance of this increased speed can be readily appreciated, as it enables a torpedo to strike the vessel at which it is discharged before she has time to get out of the way. The torpedoes are fired by a striker actuated by a spring which is released on the torpedo striking the side of the ship; the striker is pointed, and penetrates a cap charged with 38 grains of fulminate; this cap is embedded in an 8 oz. disc of dry gun-cotton, enclosed in a hermetically sealed case, and placed as nearly as possible in the centre of the wet gun-cotton charge containing 12 per cent. of water. Gun-cotton is also used as the charge for submarine mines, the charge consisting of from 50 to 500 lb. of wet compressed gun-cotton.

There are various descriptions of marine mines. (1) *Ground mines*: in these the charge is contained in a case of sheet steel, with cast-iron sinkers attached to it to keep it at the bottom of the harbour or river; these mines are fired electrically by observation from the shore when an enemy's ship passes over them. (2) *Buoyant mines*: these are anchored a few feet below the surface of the water by a steel rope attached to a sunken weight; they are connected with the shore by electric wires; a buoy with a signalling apparatus is attached to the mine, and when a ship strikes a buoy it rings a bell in the signalling-room on shore; if the ship is a friendly one it is allowed to pass, but if it is an enemy's ship the mine is fired by electricity and the ship blown up. (3) *Electro-contact mines*: these are used only in places where an enemy's ship would pass. When the mine is struck by a passing ship a steel spring or pendulum moves towards the point of impact and thus closes the circuit and fires the mine automatically.

A powder made by the Explosives Company, and generally known under the name of *E.C. Powder*, is another form in which gun-cotton can be used. There are two descriptions of this powder—viz. sporting and rifle powder; they are both essentially granulated gun-cotton, and consist of small rounded granules, the sporting powder being coloured orange with aurine, and the rifle powder yellow with picric acid.

Schultze Powder may be mentioned here as, although not strictly speaking a gun-cotton powder, it belongs to the class of explosive compounds not containing nitro-glycerine. The process of manufacture consists in macerating soft timber from which all resinous and fatty matter has been extracted by chemical means, the residue being pure finely-divided cellulose; this is saturated with nitric and sulphuric acids, and thoroughly purified by washing. The nitro compound thus formed is finely ground and waterproofed, and then sifted into the various sizes of grain required. Schultze powder has been manufactured since about the year 1860, but E.C. is a powder of more recent date. Both these powders are now largely used for sporting purposes. The great advantages they possess over the ordinary black powder are that an equal velocity is obtained with a very much smaller charge, that they do not foul the gun, and that they are nearly smokeless. But against this must be set the disadvantage that under certain conditions the strain on the breech of the gun is greater. But hitherto the results obtained from these powders when used in military firearms are not sufficiently uniform or regular to justify their adoption for military purposes. There can, however, be but little doubt that a smokeless powder of some sort will, before long, be universally adopted by all the great powers of Europe, not only for rifles, but also for artillery purposes; it is no longer a question as to whether a smokeless powder should be adopted or not, but which of all the smokeless powders experimented on is the best for adoption. Smokeless powders, in order to be suitable for military purposes, must not be too violent in their action, they must be able to stand extremes of heat and cold, they must not be very hygroscopic, and they must keep well in store without deteriorating in quality; and the problem to solve is to find a powder which will fulfil these conditions. Nearly all smokeless powders consist essentially of gun-cotton, or other lower forms of nitro-cotton, acted on by a solvent such as acetic ether or acetone, which reduces the nitro-cellulose to a viscid paste; the paste is then rolled out into sheets, and the solvent allowed to evaporate; the sheets are left as a dense horny substance, and are cut first into strips, and then the strips are cut crosswise into grains of any required size; or the substance can be left in strips or in a fibrous form.

The French, in 1887, were the first to adopt a smokeless powder for the cartridges for their new small-bore rifle, the Lebel. It is known as Vieille's powder, or 'Poudre B;' its exact composition has been kept a secret, but it is believed that picric acid is mixed with the paste as described above. The ballistics attributed to this powder when first introduced were remarkable; a charge of about 70 grains imparted a muzzle velocity of 2000 feet per second, to a bullet weighing 230 grains, fired from a rifle-barrel whose calibre was ·315". But it was found that the powder rapidly deteriorated, and that these results were only attainable with recently manufactured powder, there being a notable falling off in velocity a few months after manufacture. In consequence of this it is stated that the French in 1889 abandoned the use of this powder, and reverted to the use of a good type of black powder until they can discover a more stable one.

The Germans also in 1889 introduced a smokeless powder for their new small-bore rifle; it is a nitrated gun-cotton, but although it was very highly spoken of after the autumn manœuvres of 1889, when it was extensively tried, it is believed that like the French powder it is also wanting in stability, and that the Germans are already endeavouring to find a better description of powder.

Several patents for smokeless powder have been taken out in England, but none of them are entirely satisfactory, so that at the beginning of 1890 the subject was still under the consideration of the Explosives Committee, to whom it has been referred by the English government; and, although the difficulty of obtaining a smokeless powder of the necessary stability has not yet been surmounted, those who have the matter in hand are confident of being able to provide such a powder.

There can, therefore, be but little doubt that, as has already been mentioned, not only in England, but also on the continent of Europe, the use of smokeless powder as a propelling agent in all military firearms will be universal. Its introduction will have an immense influence, not only on drill, but also on Tactics (q.v.); and, considering its importance, the English government are wise in being extremely cautious before determining on the particular smokeless powder which will eventually be adopted. And until the question is settled the cartridge for the new English small bore rifle is made up with a compressed pellet of a particular description of black powder.

One of the most powerful explosives known is *blasting gelatine*, which it is made by dissolving 7 per cent. of gun-cotton in 93 per cent. of nitro-glycerine; it forms a gelatinous mass somewhat resembling honey in colour, and varying in consistency from a tough leathery material to a soft substance like stiff jelly. It is stronger than dynamite, as the nitro-cellulose itself is explosive, and, if made with great care, and if absolutely free from all impurities, is a safe and stable explosive. But, unless the ingredients of which it is composed are absolutely pure and free from all foreign matter, it becomes exceedingly dangerous when stored in large quantities, as the following story will show. A large quantity of this explosive was sent out to Aden to be used in the execution of the defensive works now being erected there. It was stored in two magazines situated at a considerable distance from one another. One of the magazines blew up, when extra precautions were observed at the other magazine; but after an interval of two or three months the second magazine also blew up. There was no suspicion of foul play, and after an exhaustive inquiry the conclusion arrived at was that the mass had begun to decompose owing to impurities in some of the ingredients, and that it went up by spontaneous combustion.

Gunpowder is a well-known explosive mixture composed of saltpetre, charcoal, and sulphur mixed together in certain proportions, somewhat varying in different countries and in different descriptions of powder.

The early history of gunpowder is very obscure; but there appears to be little doubt that the explosive nature of saltpetre (the great bulk of which comes either from India or China) when mixed with charcoal or carbon was known to the Chinese for many centuries before the Christian era. It may be assumed that the discovery of this property of saltpetre was accidental; a wood-fire lighted on the earth where saltpetre was mixed with the soil would bring the two ingredients together, and the action of the heat would be sufficient to show the nature or property of the mixture so brought about when raised to a certain temperature. It is certain that fireworks were known in China from very early periods; but in a pamphlet written by Colonel Omodei (Turin, 1834), and later in an article in the *Athenæum* of December 26, 1868, by Captain (now Lieut.-General) Henry Brackenbury, R.A., the question as to the first invention of gunpowder was fully discussed, and the conclusion arrived at was that there is great reason to doubt whether either the Chinese or any other Asiatic people invented gunpowder in its true sense, or were the first to use it as a propelling agent. It was left for more western nations to develop the discovery of the Chinese, and our first knowledge of the use of gunpowder as a military agent dates from the 7th century, when it was used by the Byzantine em-
powder all granulated powders are made. The meal is compressed in a press-box, the amount of compression it undergoes being dependent on the density of powder required. After compression the press-cake is broken into pieces ready for granulating, which is done in the granulating machine, the powder passing between gun-metal rollers till it is broken into grains of the required size, different powders being made to pass through sieves whose meshes are of the size of tl e grain required. There is a considerable amoun of dust formed by the granulating process, so t at after granulating it is necessary to dust the pc vder previous to glazing it, which is the next oper tion. It is glazed in glazing drums, which, revolviag rapidly, impart a glaze to the powder simply by the friction set up. The powder is now stoved or dried in copper-trays in a drying room, which is heated to a temperature of about 100° F., and the powder is left in this room from one to two hours according to the amount of moisture that it contains. Formerly all powder was granulated, but the enormous increase in the size of the guns now used necessitated the introduction of other descriptions of powder—viz. *cut* and *moulded* powders. In the cut powders, after the process of *pressing*, the press-cake, instead of being granulated, is first cut into strips, and these strips are then cut into cubes, and the powder so made is called cubical or pebble powder; there are at present two sizes—viz. ⅝-inch and 1½-inch cubes. In the moulded powders, as is implied in the name, each grain or piece of oowder is moulded or pressed

Queen Elizabeth by far the larger quantity of powder required by the English was obtained from abroad; but in her reign its manufacture was introduced into England. The earliest English powder-mills of which there is any record were established at Long Ditton and Godstone, in Surrey, by George Evelyn (John Evelyn's grandfather) in 1590; the Faversham mills were started soon after this date, as were also those at Waltham Abbey. The mills at Faversham subsequently became the government powder-factory, and in 1787 the government also bought the mills at Waltham Abbey, which have remained in its hands down to this day. The Faversham mills were given up by the government after the peace of 1815; they were soon after bought by Messrs John Hall & Son, who still retain them.

The mode of manufacture adopted in England when these several powder-mills were all thoroughly established remained practically unchanged up to within the last thirty-five years. But before proceeding with a description of the manufacture and of the different powders now in use, it will be desirable to consider very briefly the part played by the several ingredients of which gunpowder is composed, and the chemical action which takes place on ignition. The saltpetre or nitrate of potash, KNO_3, acts as a magazine of oxygen, with which it readily parts when raised to a certain temperature. When the powder is fired, the oxygen of the saltpetre converts most of the carbon of the charcoal into carbonic acid, CO_2, a portion of which combines with the potash of the nitre to form carbonate of potash, KCO_3, the remainder existing in the state of gas, and the nitrogen is liberated. The sulphur, which performs the part of a second combustible in gunpowder, is for the most part converted into sulphuric acid, SO_3, and forms sulphate of potash. The reaction on firing the gunpowder may be expressed by the equation $KO,NO_5 + S + 3C = 3CO_2 + N + KS$. The heat generated by the explosion evolves a large quantity of elastic gases, the expansive power of which is greatly increased by the heat. The pressure being equal in all directions, the work done on the projectile in the bore of the gun is due to this elasticity and expansive force. The method adopted for measuring the amount of pressure in the bore of the gun will be dealt with hereafter.

Sir Frederick Abel, C.B., F.R.S., and Captain Noble, C.B., carried out two series of most exhaustive and complete experiments on fired gunpowder, and the conclusions they arrived at were communicated by them to the Royal Society in two papers (1875-80) under the head of 'Researches on fired Gunpowder.' The results are summarised as follows: when fired in a confined space (1) the products of combustion are about 57 per cent. by weight of ultimately solid matter and 43 per cent. of permanent gases; (2) the permanent gases occupy about 280 times the volume of the original powder; (3) the tension of the products of combustion when the powder entirely fills the space in which it is fired is about 6400 atmospheres, or 42 tons per square inch; (4) the temperature of explosion is about 4000° F.; (5) the chief gaseous products are carbonic acid, nitrogen, and carbonic oxide; (6) the solid residue is mainly composed of potassium carbonate, sulphide, and sulphate.

From the foregoing description of the part played by the nitrate of potash it might be thought that it would be highly advantageous to make gunpowder with some nitrate containing a larger percentage of oxygen than nitrate of potassium; and as a matter of fact there are a large number of nitrate mixtures other than gunpowder in which nitrate of sodium, barium, or ammonium are substituted for the nitrate of potassium. But unfortunately they are extremely hygroscopic, so that gunpowder made with them would, under ordinary circumstances, soon become useless on account of the damp it would absorb from the atmosphere. In a hot dry climate nitrate of soda powders would doubtless be valuable, besides being much cheaper to manufacture than nitrate of potash powders: indeed such powders were used to a considerable extent in the construction of the Suez Canal; but, as these powders are not in general use, it is unnecessary to refer to them further.

Process of Manufacture.—The method of manufacture of gunpowder at the Royal Gunpowder Factory at Waltham Abbey (fully explained in the official handbook) may be briefly described. As in all other explosives, it is essential that the ingredients of which the powder is composed should be as pure as possible. The selection and preparation of the charcoal is of the greatest importance; for, without any change in the proportions of the components, the properties of the gunpowder are capable of great variation from the quality of the charcoal used in its manufacture. The ingredients are first reduced to a fine powder by grinding. They are then mixed by hand in the proportion of 75 per cent. by weight of saltpetre, 15 of charcoal, and 10 of sulphur, and are next thoroughly incorporated in a wet state in a powder-mill into a cake called a mill-cake. This cake is then broken down between copper-plates into meal. From this meal-

powder all granulated powders are made. The meal is compressed in a press-box, the amount of compression it undergoes being dependent on the density of powder required. After compression the press-cake is broken into pieces ready for granulating, which is done in the granulating machine, the powder passing between gun-metal rollers till it is broken into grains of the required size, different powders being made to pass through sieves whose meshes are of the size of tl e grain required. There is a considerable amoun of dust formed by the granulating process, so t at after granulating it is necessary to dust the pc vder previous to glazing it, which is the next oper tion. It is glazed in glazing drums, which, revolviag rapidly, impart a glaze to the powder simply by the friction set up. The powder is now stoved or dried in copper-trays in a drying room, which is heated to a temperature of about 100° F., and the powder is left in this room from one to two hours according to the amount of moisture that it contains. Formerly all powder was granulated, but the enormous increase in the size of the guns now used necessitated the introduction of other descriptions of powder—viz. *cut* and *moulded* powders. In the cut powders, after the process of *pressing*, the press-cake, instead of being granulated, is first cut into strips, and these strips are then cut into cubes, and the powder so made is called cubical or pebble powder; there are at present two sizes—viz. ⅝-inch and 1½-inch cubes. In the moulded powders, as is implied in the name, each grain or piece of powder is moulded or pressed
in a separate mould. This is done in a hydraulic machine. The exact quantity of granulated powder required to form each prism is deposited in a block containing sixty-four moulds; the powder in these moulds is then pressed by plungers exactly fitting the moulds till the required density is obtained. This powder is called *prismatic powder*, the grains or pellets being in the form of hexagonal prisms nearly 1 inch in height and about 1⅜ inch across, with a hole in the middle about $\frac{1}{10}$th of an inch in diameter, the object of which will be explained later on. There are two descriptions of prismatic powder—black and brown. The proportions of ingredients in the black powder are the same as in all other English military powders; but in the brown powder the charcoal is made from straw, instead of from wood, and the proportion of the ingredients are as follows: viz. saltpetre 79, charcoal 18, and sulphur 3 per cent.

Gunpowder more nearly fulfils the objects required in a propelling agent than any other explosive hitherto discovered. These objects are (1) a maximum muzzle velocity with even and low pressures; (2) uniformity of action, so that the same results may always be expected; (3) freedom from fouling; (4) durability—i.e. that it is not liable to injury in transport, and that its condition does not materially alter when stored.

The advantages of gunpowder over other explosives are (1) that, the rate of combustion being gradual, the explosion is not so severe on the bore of the gun as in the case of more violent explosives; (2) the ingredients of which it is composed are easily produced and are cheap; (3) it is, with proper precautions, safe in manufacture, in store, or in transport. Experiments made by the Explosives Committee have shown that any alteration in the proportions of the ingredients has not so great an influence on the 'explosiveness' or rate of burning as the density, hardness, size, and shape of grain and amount of glaze. The density of grain has an important effect on the rate of burning. By absolute density is meant the amount of powder actually present in a certain bulk—i.e. if different quantities of meal-powder, containing an equal amount of moisture, be pressed into cakes of the same size, that which contains the most meal will be densest; then, if these cakes be ignited simultaneously, the cake which has the least density will be the first to be completely burnt. Hardness does not depend on density; increased hardness is given by pressing the meal in a moister condition. Size and shape of grain are also important characteristics to be considered in connection with the explosiveness of powder. Other things being equal, a larger-grained powder burns slower than a smaller-grained; and in grain of equal weight that which has the largest surface will burn the quickest. A highly-glazed powder, again, burns slower than an unglazed one, probably because the glaze somewhat retards its thorough ignition. The temperature at which powder ignites varies from 530° to 600° F., according to the nature of the powder, the finest sporting powder igniting at the higher temperature.

It is only of late years that all these points have received the attention they deserve, but they have been forced upon the authorities by the necessities of the times. As soon as ships began to be plated with armour, guns had to be made which could throw a projectile capable of piercing that armour; and as the armour increased in thickness so did the guns increase in size and power, throwing heavier projectiles, which necessitates an enormous powder charge to propel the shot. In former days there was a beautiful simplicity about powder. Practically there were but two kinds, one for muskets called fine grain or F.G., and the other for cannon called large grain or L.G., and no particular attention was paid to the quality; it was certainly not subjected to the searching proofs and tests which all powders made in these days have to undergo. The first improvement in powder took place on the introduction of rifled arms, when a rifle fine-grain powder or R.F.G., slightly larger in the grain than F.G., and a rifle large-grain powder or R.L.G., the grains of which were about twice the size of those of L.G., were introduced for small-arms and cannon respectively. The R.F.G. powder was improved and made of a rather smaller grain, the size of grain being from $\frac{1}{16}$th to $\frac{1}{20}$th of an inch, on the introduction of the Martini-Henry rifle, and this powder, known as R.F.G.², has not since been altered. But in cannon powder, or powder for large guns, the development has been great and continuous. When R.L.G. powder was introduced it was the largest grained and slowest burning powder then in existence in England; but as the guns were made larger and larger it became necessary to use a slower-burning powder, which led first to the introduction of R.L.G.², having grains varying in size from 3 to 6 to the inch; that is, the grains must pass through a sieve of 3 meshes to the inch, and must not pass through one of 6 meshes to the inch. A short time afterwards a still larger powder called R.L.G.⁴, with grains of nearly half an inch in size, was introduced. This was soon followed by pebble powder, a still further development of R.L.G., for guns of large calibre for which R.L.G.⁴ was not suitable. The first pattern of pebble or P. powder was cut in cubes of about half an inch in size, and a second pattern or P.² was made in cubes of about $1\frac{1}{2}$ inch in size, with rounded edges. Both these powders have a density of 1·75, whereas that of the R.L.G. powders is 1·65. Next in order came the prismatic powders, of which there are two descriptions—viz. prismatic black or Prism¹ and prismatic brown or Prism¹ brown, a description of which has been given under the head of manufacture. There are two other powders of a special pattern which may be mentioned—viz. M.G.¹ which is used only in the 1-inch Nordenfelt machine gun, the size of grain of which is considerably larger and of more even size than that of R.F.G.²; and Q.F.¹, a powder which at present is used only in the 3- and 6-pounder quick-firing guns, the size of grains being about half an inch square by about $\frac{1}{10}$ of an inch thick.

The powders of other nations differ but slightly from those manufactured in England; the method of manufacture is the same in principle, but the proportions of the ingredients vary to a slight degree in every nation.

Having now described the various powders in use, it remains to say a few words about velocities and pressures. The great desideratum with all firearms is to obtain the maximum velocity with the minimum of pressure, and in the experiments and investigations carried out by the committee on explosives, and by Sir F. Abel and Captain Noble, this end was kept in view. It has already been pointed out that the rate at which powder burns depends greatly on the density, hardness, size, and shape of grain: the greater the density the slower it will burn; the larger the grain the slower it will burn, simply because the amount of lighting surface is reduced in proportion to the volume; and the smoother the surface of the grain the slower it will burn for the same reason. A powder therefore composed of, comparatively speaking, small grains of irregular size and shape, burns very rapidly, and generates a large volume of gas suddenly, thus setting up a very high pressure in the bore of the gun. In some of the experiments of the committee the pressure recorded in the bore of the gun was as high as 60 tons to the square inch; but, as Captain Noble had previously discovered that the maximum pressure of powder fired in a confined space did not exceed 42 tons, this extra pressure could only be due to wave-action, a sudden evolution of gas locally causing a vibratory motion of the gas. This led to the introduction of larger-grained powders, so as to retard the burning of the charge, but this did not entirely do away with the wave pressure. It was next sought to diminish the pressure by giving air-space to the charge, as it was found that the density of the charge—not the density of the grain—materially affected the pressure; this air-space was given by enlarging the chamber of the gun, and although it became necessary to increase the charge so as to maintain the same muzzle velocity, it was found that the pressure was sensibly diminished.

But whilst Great Britain was still adhering to pebble powder, other nations had adopted a prismatic powder with a hole through the centre of the pellets or prisms. The idea of this perforated powder is due to General Rodman, an American artillery officer, who thought that by this means a charge of powder would evolve the gas at a more uniform rate. In a charge composed of solid grains, the grains being lighted on the surface and burning towards the centre, the surface giving off gas rapidly decreases, and therefore the volume of gas given off by the grain will be greatest when the charge is first fired, and will rapidly fall off; hence the maximum pressure on the bore of the gun is set up almost before the projectile commences to move. To overcome this, the idea occurred to General Rodman to have a hole through each large grain or pellet of powder, so as to give the grain an interior as well as an exterior lighting surface, so that as the exterior lighting surface *decreased* the interior lighting surface *increased*, thus preserving the ignited surface more uniform during the burning of the pellet, and therefore keeping up a more constant evolution of gas. This tends to distribute the pressure more uniformly along the bore of the gun, and increases the initial velocity of the projectile. The Russians in 1860 were the first to adopt this plan, followed by the Germans, the English being the last to take it up; it is now, however, adopted for the heaviest guns in the English service, the charge being built up of the hexagonal prisms already described, so arranged that the holes through each column of prisms shall be continuous from one end of the charge to the other. The introduction of this powder has enabled the type of gun to be entirely altered; a description of the guns now in the service will be found under the head of Cannon, Rifles (q.v.). We are indebted to the Germans for the invention of brown or cocoa powder; it is claimed for this powder that it gives a higher initial velocity with less pressure than the same charge of black powder.

The same principles as have been enunciated here with regard to guns should govern the selection of powder for mining or blasting purposes. If it is desired to shatter a mass of rock, a very violent quick-burning powder, having a great disruptive force, should be used; but if it is only desired to dislodge, say, a mass of coal without shattering it, a denser, slower-burning powder should be chosen.

The instrument generally used for taking velocities is a chronograph, the invention of Major De Boulengé of the Belgian Artillery. It consists of a brass column supporting two electro-magnets. No. 1 electro-magnet supports a long cylindrical rod, called the chronometer, covered by a zinc tube; No. 2 electro-magnet supports a shorter rod. Two screens of copper wire are placed at certain fixed distances in front of the muzzle of the gun. No. 1 electro-magnet is magnetised by the current passing through the first screen, and No. 2 by the current passing through the second screen. As the shot passes through the first screen the current is broken, and the rod or chronometer suspended by No. 1 electro-magnet falls by gravity. Similarly, when the shot passes through the second screen, the shorter weight suspended by No. 2 electro-magnet falls on to a disc, which, pressing a spring, causes a knife to be released, and this, darting forward, strikes the chronometer in its fall, making an indent in the zinc tube. The distance of this indent from the zero point being measured off on a scale specially graduated for the instrument gives the velocity of the shot between the two screens, from which can be calculated the muzzle velocity. Another scale gives the time of flight.

The pressures in the bore of the gun are calculated by means of a crusher gauge. A small copper cylinder is inserted in the gauge, which is screwed into the gun at that part where it may be desired to measure the pressure. The copper cylinder is measured before and after the discharge of the gun, the amount by which it is shortened by the force of the explosion being the measure of the force, or pressure, exerted. The actual pressure in tons to the square inch is calculated by means of a mathematical table prepared for different coppers.

Gutta-percha, a substance in many respects similar to caoutchouc, is the dried milky juice of various trees of the order Sapotaceæ; the chief is apparently that called by Hooker *Isonandra Gutta*, and by Bentley and Trimen *Dichopsis Gutta*. The tree, which is found in the peninsula of Malacca and the Malayan Archipelago, is very large, attaining a height of 70 feet; the trunk is sometimes 3 or even 4 feet in diameter, although it is of little use as a timber-tree, the wood being spongy. The leaves are alternate, on long stalks, obovate-oblong, entire, somewhat leathery, green above, and of a golden colour beneath. The flowers are in little tufts in the axils of the leaves, small, each on a distinct stalk, the corolla having a short tube and six elliptical segments; they have twelve stamens and one pistil. The name, gutta-percha (*gatta pârcha*, or *gittah pertja*), is Malay. There are two or three kinds of gutta-percha known in commerce, and it is more than probable these are

Gutta-percha (*Isonandra* (*Dichopsis*) *Gutta*): *a*, a flower; *b*, fruit.

yielded by different species. That from Singapore is esteemed the best, and is distinguished by the Malay traders as *Gutta Taban* or *Tuban*; that of Borneo is of less value—this is called *Gutta Percha* by the traders, and has given the general name to all; and another kind goes by the name of *Gutta Girek*. The first two are those generally known in our markets. The former mode of obtaining the gutta-percha was a most destructive one. The finest trees were selected and cut down, and the bark stripped off; between the wood and bark a milky juice was found, which was scraped up into little troughs made of plantain leaves. Now the plan of tapping the living trees is employed. The juice soon coagulates, or may be boiled, and is then kneaded by hand into oblong masses a foot in length.

Gutta-percha was known in Europe long before its peculiar characteristics and uses were known. It was brought home at various times by voyagers, in the forms of drinking-bowls and native shoes; and was thought by some to be a species of india-rubber, while others asserted it was a kind of wood, which they named *mazer-wood*. But for its introduction in 1843 we are indebted chiefly to Dr William Montgomerie of the Indian Medical Service, who was rewarded with the gold medal of the Society of Arts. He first noticed that the Malays used it for making handles to their knives, &c., and it immediately occurred to him that it might be of great use in a variety of ways, especially in making handles for surgical instruments, the hand being able to get a light but firm grasp of them. Soon the importation of gutta-percha increased amazingly; in 1860 it exceeded 16,000 cwt. In 1864, 1865, 1870, and 1871 the imports varied from 25,966 cwt. to 35,636 cwt.; in 1876-83, from 21,100 cwt. to 66,000 cwt. Down to 1888 these imports declined very much, as in that year they only reached 22,500 cwt., at an average price of 162 shillings per cwt. In 1889, however, they showed an upward tendency both in quantity and value, the total imports from January to October 1889 being 38,940 cwt., and the average price 241 shillings per cwt. By far the greatest portion of it is imported from the East Indies.

Its most important application has been in the coating of marine electric telegraph wires. In this application, as in most others, its inherent defect, arising from the readiness with which it becomes oxidised and decomposed, has manifested itself seriously, and it is greatly affected by age in its resisting qualities. Hence substitutes of greater stability have been looked for. Many of these have been forthcoming, india-rubber being used now to a large extent, as also a composition produced from asphalt, balsam of sulphur, &c., and other compounds. Gutta-percha is used for making a vast variety of useful and ornamental articles. Among others the following may be mentioned: golf-balls (very extensively), overshoes (more in America than in Britain), beltings for machinery, pump-buckets, sheeting, tissue, thread or whip cord, and tubing. A very large trade is done in shoe soles. It is turned by surgeons to various uses, chiefly for splints and moist coverings to retard evaporation. It has also been used for stopping hollow teeth.

The great value of gutta-percha arises from the ease with which it can be worked, and its being so complete a non-conductor of electricity. It softens in warm water, and can be moulded into any form in that state, as when soft it is not sticky and turns well out of moulds. It will always be of great value as a material in which to take casts, as it can in the soft state be made to take the sharpest forms most faithfully; and, as it quickly becomes hard, and preserves its shape if not too thin, the range of its utility in this respect is very extensive.

It is imported in blocks and lumps of five to ten pounds weight, in various forms, chiefly like large cakes, or rounded into gourd-like lumps. It has a very light reddish-brown, or almost a flesh colour, is full of irregular pores elongated in the direction in which the mass has been kneaded. It has a cork-like appearance when cut, and a peculiar cheese-like odour. Before it can be used it has to undergo some preparation. This consists in slicing the lumps into thin shavings, which are placed in a *devilling* or tearing machine revolving in a trough of hot water. This reduces the shavings to exceedingly small pieces, which, by the movement of the tearing-teeth, are washed free from many impurities, especially fragments of the bark of the tree, which, if not separated, would interfere with the compactness of its texture—one of its most important qualities. The small fragments, when sufficiently cleansed, are kneaded into masses; and these are rolled several times between heated cylinders, which press out any air or water, and render the mass uniform in texture. It is then rolled between heated steel rollers into sheets of various thicknesses for use, or is formed into rods, pipes for water, speaking-tubes, or any of the innumerable articles which may be made of it.

Gutta-percha differs very materially from caoutchouc or india-rubber in being non-elastic, or elastic only in a very small degree. Notwithstanding this very striking character of caoutchouc, the two articles are very often confounded in the public mind.

Gypsum is a valuable mineral of a comparatively soft nature. Chemically it is a hydrated sulphate of lime, $CaSO_4 + 2H_2O$. Its specific gravity is 2·31, and its hardness is from 1·5 to 2 of the mineral scale. The massive marble-like variety, which is usually white or delicately tinted and translucent, is called Alabaster (q.v.); when transparent and crystallised it is known as Selenite (q.v.); and when fibrous and with a pearly opalescence it is termed satin spar.

Gypsum occurs in various geological formations, and has a wide geographical distribution. Extensive beds of the common variety are generally made up of irregular, concretionary, nodular masses. In the New Red formation near Derby, at Carlisle, and in some parts of Nottinghamshire, as well as in the Tertiary beds of the suburbs of Paris, it is largely worked for the preparation of plaster of Paris. Productive beds of it are found in numerous localities in the United States, principally in Ohio and Michigan; in New Brunswick, Nova Scotia, and Ontario; and in the Punjab. Gypsum is very frequently associated with rock-salt.

Gypsum contains 21 per cent. of water, which can be driven off by heat. It is burned in kilns at or a little below a temperature of 250° F., and afterwards ground to a fine powder, which is called *plaster of Paris*. This recombines with water, evolves heat, and almost immediately solidifies or *sets*. It is this property which makes it so serviceable for many purposes in the industrial arts. If in the burning of gypsum the temperature is raised as high or higher than 480° F. it loses the power of rehydrating, and is then said to be *dead burnt*, in which state it will not set when mixed with water. Like gypsum, plaster of Paris is soluble to the extent of rather more than 2 parts in 1000 parts of water at ordinary temperatures, its point of maximum solubility being 95° F. It is therefore unsuited for external work, except in dry climates such as that of Persia. For making casts the plaster of Paris is made up with water to a consistency of thick cream. In this state it is poured into a mould, which is usually also made of the same material, and left to solidify. Some oil, such as olive, is brushed over the mould to form a *parting* between it and the cast. Plaster of Paris is most extensively used for taking casts of sculpture and architectural details, as well as for casts of small objects such as coins, medals, and engraved gems. For pottery moulds it is also largely employed, and it is used to take a first copy from the modelled clay in the production of metal patterns. Large quantities of it are consumed for the mouldings of the internal plasterwork of houses, and for cornice and other ornaments. For hardened plaster of Paris, such as Keene's cement, see CEMENTS; and for the agricultural applications of gypsum, see MANURES. Gypsum is one of the substances which renders water hard, and such water is useful in the brewing of some kinds of beer. *Pearl hardening*, used as a filling in the manufacture of some kinds of paper, is an artificial sulphate of lime, precipitated by sulphuric acid from chloride of calcium. *Fictile Ivory* is plaster of Paris which has been made to absorb beeswax, spermaceti, and stearic acid, in their melted state.—The average annual production of gypsum in Great Britain is nearly 120,000 tons, value about £48,000. In 1868 the production of the United States was about 96,000 tons; of Nova Scotia, 126,118 tons. For the anhydrous sulphate of lime, see ANHYDRITE.

Gypsy-wort (*Lycopus europæus*), sometimes also called Water Horehound, is a perennial plant belonging to the natural order Labiatæ. It is a tall erect branching plant, slightly hairy, with a creeping root-stock. It is common in moist places in Britain, the Continent, Russian and central Asia, and North America; and is regarded as a febrifuge and astringent. It dyes black, and gives a permanent colour to wool, linen, and silk, and as long ago as 1578 the Gypsies were fabled to stain their skin with it. The Bugle-weed of North America (*L. virginicus*) has more powerfully astringent properties.

Gyroscope (Greek) is the name given to an instrument for the exhibition of various properties of rotation and the composition of rotations. It differs from a top in having both ends of its axis supported. The invention is probably French or German, and in some of its forms it dates from about the end of the 18th century.

If a mass be set in rotation about its principal axis of inertia of greatest or least moment, it will continue to revolve about it; and, unless extraneous force be applied, the direction of the axis will remain unchanged. Such, for instance, would be the case with the earth, were it not for the disturbances (see NUTATION and PRECESSION) produced by the sun and moon; the direction of the axis would remain fixed in space. It is for this very reason that modern artillery is rifled. If, then, a mass of metal, as, for instance, a circular disc, loaded at the rim, and revolving in its own plane, be made to rotate rapidly about its axis of greatest moment of inertia, and if it be freely supported (in gimbals, like the box of a compass), the direction of its axis will be the same so long as the rotation lasts. It will therefore constantly point to the same star, and may, of course, be employed to show that the apparent rotation of the stars about the earth is due to a real rotation of the earth itself in the opposite direction. This application was made by Foucault shortly after his celebrated Pendulum (q.v.) experiment, as it had been many years before (March 1836) by Dr Sang (see the *Trans. of the R. Scot. Soc. of Arts*). It is, in practice, by no means so perfect a mode of proving the earth's rotation as the Foucault pendulum; but this arises solely from unavoidable defects of workmanship and materials. Professor Piazzi Smyth has applied this property of the gyroscope to the improvement of our means of making astronomical observations at sea. A telescope, mounted on the same support as the ends of the axis of the gyroscope, will, of course, be almost unaltered in position by the rolling or pitching of a vessel; and a steady horizon, for sextant observations of altitude, may be procured by attaching a mirror to the support of the gyroscope, and setting it once for all by means of spirit-levels.

But the most singular phenomena shown by the gyroscope are those depending on the *composition* of rotations (see ROTATION). Any motion whatever of a body which has one point fixed is of the nature of a rotation about an axis passing through that point. Hence, simultaneous rotations about any two or more axes, being a motion of some kind, are equivalent to a rotation about a single axis. The effect, then, of impressing upon the frame in which the axis of the spinning gyroscope is suspended a tendency to rotate about some other axis, is to give the whole instrument a rotation about an intermediate axis; and this will coincide more nearly with that of the gyroscope itself, as the rate of its rotation is greater. The compound motion consists in the rolling of an imaginary cone fixed in the gyroscope upon another fixed in space; the rotation of the axis of a top round the vertical (when it is not 'sleeping' in an upright position), and the precession of the earth's axis,

Gyroscope.

are precisely similar phenomena. Thus, when the gyroscope is spinning, its axis being horizontal, a weight attached to the framework at one end of the axis (fig. *b*) makes the whole rotate about the vertical; attached to the other end, the rotation takes place in the opposite direction. And the framework may be lifted by a string attached near one end of the axis (fig. *a*) without the gyroscope's falling. Its axis still projects horizontally from the string, but it revolves as a whole round the string. Various other singular experiments may be made with this apparatus; and others, even more curious, with the gyrostat of Sir W. Thomson, which is simply a gyroscope enclosed in a rigid case, by which the ends of its axis are supported. When a gyrostat is made the bob of a pendulum under certain conditions, the plane of vibration of the pendulum turns, as in Foucault's celebrated experiment, but in general at a much greater rate.

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The Art of Dyeing. The art of fixing coloring matters uniformly and permanently in the fibres of wool, silk, linen, cotton, and other substances. Dyeing is a chemical process, and the mode of its performance depends upon the substance operated on. Thus it is found that the process by which wool is dyed black, would only impart a rusty brown to linen. *Wool* unites with almost all coloring matters with great facility, *silk* in the next degree, *cotton* less easily than silk, and *linen* with even more difficulty. Preparatory to the operation of dyeing, each of these substances undergoes a species of preparation to free the fibres from adhering foreign matter, as dirt, grease, &c. which would prevent the absorption of the aqueous fluid to be afterwards applied, as well as impair the brilliancy of the dye. *Wool* is cleaned or scoured by means of a weak alkaline lye, soap and water, or putrid urine; the latter being very generally used for this purpose. *Silk* is cleaned from the natural varnish that covers it, by boiling with white soap and water. *Cotton* and *linen* are cleaned with alkaline lyes of more or less density. The substances so prepared are ready to undergo the various operations of dyeing.

Among the various coloring materials employed by dyers, some impart their tints to different substances by simple immersion in their infusions or decoctions, and have hence been called "*substantive colors;*" but by far the greater number only impart a fugitive dye, unless the fibres of the stuff have been previously filled with some substance which has a strong affinity for the latter on the one hand, and the coloring material on the other. The substances applied with this intention are called "*Mordants,*" and generally exercise the double property of "*fixing*" and "*striking*" the color. Thus, if cotton goods be dyed with a decoction of madder, it will only receive a fugitive and dirty red tinge, but if it be first run through a solution of acetate of alumina, dried at a high temperature, washed, and then run through a madder bath, it will come out a permanent and lively red. The principal mordants are the acetates of iron and alumina, sulphate of iron, alum, and some other chemical salts. A perfect knowledge of the effect of mordants on different coloring substances is of paramount importance to the dyer.

After having received the proper mordants, the goods are dried and rinsed, after which they are passed for a shorter or longer time through an infusion, decoction, or solution of the dyeing materials, which constitute the "*dye-bath*"; they are again dried and rinsed. In many cases, the immersion in the dye-bath is repeated, either with the same materials or with others to vary or modify the color. After the substances have been properly dyed, they are subjected to a thorough rinsing or washing in soft water, until the latter runs off uncolored.

94. Dye Woods, &c. Decoctions of the different woods are prepared for general use in the dye house as they are required. If the wood be in the chipped state, it must be boiled for an hour, in the proportion of 1 pound of wood to 1 gallon of water; a second boiling is generally given with new water, and the liquor obtained used instead of water with more new wood. This second liquor is not good for dyeing alone, but when employed instead of water for new wood, ¾ pound of new wood is sufficient. The second liquor may, however, be used as an auxiliary in the dyeing of compound colors, such as browns, drabs and fawns. If the wood be ground the same quantity is taken—namely, 1 pound for each gallon of the decoction required, and is prepared as follows:—on a piece of coarse cloth stretched upon a frame, or laid into a basket, put the ground wood, and place it over a vessel, then pour boiling water over the wood until the liquor that runs through is nearly colorless. Barwood and Camwood are always used in the ground state, the wood being put into the boiler along with the goods; no decoctions of these woods are made. Decoctions of bark and weld are often formed by putting them into a coarse canvas bag, and then suspending it in boiling water.

The coloring principle of archil is highly soluble in hot water, and is useful in combination with other dyeing materials; but used alone, does not impart a permanent color.

95. To prepare Annotto. Into 2 gallons of water put 1 pound of Annotto, 4 ounces of pearlash, and 2 ounces of soft soap, and apply heat, stirring until the whole is dissolved. When convenient it is best to boil the solution.

96. To prepare Catechu. To 7 or 8 gallons of water put 1 pound of catechu, and boil till it is all dissolved; then add 2 ounces of sulphate of copper, stir, and it is ready for use. Nitrate of Copper may also be used, taking 1 wine-glassful of the solution made according to the next receipt.

97. To make Nitrate of Copper Solution. To 1 part by measure nitric acid, and 2 parts water, add metallic copper so long as the acid will dissolve it, then bottle the solution for use.

98. To make Sulphate of Indigo. Into 5 pounds of the most concentrated sulphuric acid, stir in by degrees 1 pound of the best indigo, finely ground; expose this mixture to a heat of about 160° Fahr. for 10 or 12 hours, stirring it occasionally; a little rubbed upon a window-pane should assume a purple-blue color.

99. To make Indigo Extract. This is prepared by proceeding exactly as stated for sulphate of indigo and then diluted with about 4 gallons hot water, and the whole put upon a thick woolen filter, over a large vessel, and hot water poured upon the filter, until it passes through nearly colorless; the blackish matter retained upon the filter is thrown away, and the filtered solution is transferred to a leaden vessel, and evaporated to about 3 gallons, to which is added about 4 pounds chloride of sodium (table salt) and well stirred; the whole is again put upon a wooden filter and allowed to drain. The extract remains as a thin pasty mass upon the filter, and is ready for use.

100. To make Red Liquor. Into 1 gallon hot water place 2 pounds alum; dissolve, in a separate vessel, 2 pounds acetate of lead in 1 gallon water; in a third vessel dissolve ½ pound crystallized soda; mix all the solutions together and stir well for some time, then allow to stand over night; decant the clear solution which is ready for use.

101. To make Caustic Potash. To 3 gallons water add 2 pounds either black or pearl ashes, and boil; when seething add newly-slaked lime, until a small quantity taken out does not effervesce when an acid is added to it. To test this, take a tumbler half filled with cold water, put a table-spoonful of the boiling lye into the tumbler, and add a few drops sulphuric acid; if the acid were added to the hot lye, it would spurt up and endanger the operator. When the addition of acid causes no effervescence, the boiling and adding of lime is stopped, and the whole allowed to settle; then remove the clear liquid into a vessel having a cover, to prevent it from taking carbonic acid from the air. This serves as a stock for general use. The lime sediment remaining may have some hot water added, which will give a strong lye, and may be used for first boils for yarn or heavy cloth.

102. To make Caustic Soda. For every gallon water add 1 pound soda ash, or 2 pounds crystallized soda (washing soda); boil and proceed by adding slaked lime, and testing as for potash; boiling for some time is essential in order to ensure perfect causticity.

103. To make Lime-water. Take some well and newly-burned limestone, and pour water over it as long as the stone seems to absorb it, and allow it to stand; if not breaking down freely, sprinkle a littile more water over it. A small quantity is best done in a vessel, such as an old cask, so that it can be covered with a board or bag. After being slaked, add about 1 pound of it to every 10 gallons cold water, then stir and allow to settle; the clear liquor is what is used for dyeing. This should be made up just previous to using, as lime-water standing attracts carbonic acid from the air, which tends to weaken the solution.

104. To Make Bleaching Liquor. Take a quantity of bleaching powder (chloride of lime) and add to it as much water as will make it into a thin cream; take a flat piece of wood, and break all the small pieces by pressing them against the side of the vessel, then add 2 gallons cold water for every pound of powder; stir well, put a cover upon the vessel, and allow the whole to settle. This will form a sort of stock vat for bleaching operations.

105. To make a Sour. To every gallon of water add 1 gill of sulphuric acid, stir thoroughly; goods steeped in this should be covered with the liquor, as pieces exposed become dry, which deteriorates the fibre; if left under the liquor the cloth is not hurt by being long in the sour, but on being taken out, every care should be taken to wash out the liquor thoroughly, otherwise the goods will be made tender.

106. To make Cochineal Liquor or Paste. Put 8 ounces ground cochineal into a flask and add to it 8 fluid ounces ammonia and 8 ounces water; let the whole simmer together for a few hours, when the liquor is ready for use.

107. Acid Preparations of Tin. The acid preparations of tin used in dyeing are called *spirits*, with a term prefixed to each denoting their particular application, as red spirits, barwood spirits, &c. The tin employed for making these preparations has to undergo a process called *feathering*, and is as follows:—the tin is melted in an iron pot, and then poured from some height into a vessel filled with cold water; this granulates or feathers, the tin. (*See No.* 3319.)

108. Red Spirits are made by mixing together in a stoneware vessel, 3 parts by measure hydrochloric acid, 1 part nitric acid, and 1 part water, and adding to this feathered tin in small quantities at a time, until about 2 ounces tin to the pound of acid used are dissolved. In this operation the temperature should not be allowed to rise. (*See No.* 4124.)

109. Yellow Spirits are prepared in the same way, only substituting sulphuric acid for the nitric acid. This is used for the same purposes as red spirits, with the advantage of the economy of sulphuric over nitric acid.

110. Barwood Spirit is prepared by using 5 measures hydrochloric acid, 1 nitric acid and 1 water, dissolving in this 1 ounce feathered tin for every pound of the whole mixture. 1½ ounces tin may be used if the red dye is required to be very deep.

111. Plumb Spirit is made by using 6 to 7 measures hydrochloric acid to 1 nitric acid and 1 water, dissolving in it 1½ ounces tin for each pound of the acid mixture. This spirit is named from a preparation made with it and a decoction of logwood. A strong solution of logwood is made and allowed to cool, then to each gallon of the solution there is added from 1 to 1½ pints of the spirit: the whole is well stirred and set aside to settle. This preparation has a beautiful violet color, and silk and cotton are dyed of that shade by dipping them into this *plumb liquor* without any previous mordant. The depth of tint will depend on the strength of the solution.

112. Plumb Spirit for Woolen Dyeing. This is prepared by adding tin to nitric acid in which a quantity of chloride of ammonium (sal ammoniac) has been dissolved. Observe, that all these spirit preparations are varied by different operators, some preferring more or less of the two acids, and also of the tin; but the proportions given form good working spirits, and if care be taken in their preparation not to *fire* them, that is, not to allow the temperature to get so high as to convert the tin into a persalt, the operator will not fail in his processes as far as the quality of the spirit is concerned.

113. Tin Spirits. The following are among the best recommended preparations of tin spirits, used for dyeing scarlet:

1 pound nitric acid, 1 pound water; dissolve in this 1½ ounces sal ammoniac, and then add, by degrees, 2 ounces pure tin, beaten into ribbons.

Or: dissolve 1 part sal ammoniac in 8 parts nitric acid at 30° Baumé; add, by degrees, 1 part pure tin; and dilute the solution with one-fourth its weight of water.

Or: 4 parts hydrochloric acid at 17° Baumé, 1 part nitric acid at 30° Baumé; dissolve in this mixture 1 part pure tin.

Or: 8 parts nitric acid, 1 part sal ammoniac or common salt, and 1 part grain tin. This is the common spirit used by dyers.

114. Alum Plumb. Make a strong decoction of logwood, and then add to it 1 pound alum for every pound of logwood used.

115. To Test the Purity of Alum. The usual impurity which renders alum unfit for the uses of the dyer, is the ferro-sulphate of potassa, but if iron be present in any other shape it is equally injurious. Common alum frequently contains ammonia, from urine or the crude sulphate of the gas works having been employed in its manufacture. This may be detected by adding a little quicklime or caustic potassa. Pure alum should form a colorless solution with water, and give a white precipitate with pure potassa soluble in an excess of the latter. It should suffer no change on the addition of tincture of galls, prussiate of potash, or sulphureted hydrogen.

116. Nitrate of Iron is used in the dye-house for various purposes. Its principal use is for dyeing Prussian Blue, and is obtained as follows: Take 4 parts nitric acid and 1 part water in a glass or stoneware vessel; place it in a warm bath, and add clean iron so long as the acid continues to dissolve it with effervescence; take out any iron that remains undissolved, and, after settling for 1 hour, the clear solution is ready for use. The fumes given off during the operation should be guarded against, being deleterious to health and injurious to any metal or vegetal with which they come in contact. This solution should be kept in the dark, as it loses some of its strength by exposure to light.

117. Chloride of Iron is another salt used in the dye-house for dyeing silks and woolens a deep blue, and is preferred, for that purpose, to copperas. It is prepared for use thus: To 4 parts hydrochloric acid add 2 parts water, and apply a gentle heat; then add iron in pieces, or filings, so long as it continues to be dissolved; then pour off the clear liquid into a basin, and evaporate, when greenish colored crystals of chloride of iron will be obtained. This salt crystallizes with difficulty, deliquesces in the air, and should not be exposed. Instead of evaporating and crystallizing, the solution may be put in a bottle and reserved for use.

118. To make Iron Liquor. Into a large cast-iron boiler, or pot, a quantity of iron turnings, hoops or nails, are introduced, and acetic acid—the crude pyroligneous acid from the distillation of wood—is poured in upon them. The strength of the acid is generally of 5° Baumé, or specific gravity 1.035. A temperature of 150° Fahrenheit is maintained till the solution of protoacetate of iron is obtained. During the solution of the iron much tarry matter separates, which is skimmed off, and the solution frequently agitated, to free it, as much as possible, from the tar. As soon as a strength is gained of a specific gravity of 1.09, at 60° Fahrenheit, the solution is allowed to cool, for a further quantity of impurities to separate. When clean turnings are operated on, the process of solution is completed in 5 to 7 days.

119. To make up a Blue Vat. Take 1 pound indigo, and grind in water until no grittiness can be felt between the fingers; put this into a deep vessel—casks are generally used—with about 12 gallons water; then add 2 pounds copperas, and 3 pounds newly-slaked lime, and stir for 15 minutes; stir again after 2 hours, and repeat every 2 hours for 5 or 6 times; towards the end, the liquor should be of a greenish yellow color, with blackish veins through it, and a rich froth of indigo on the surface. After standing 8 hours to settle, the vat is fit to use.

120. To make Blue Stone. Sulphate of copper is known in commerce as *Blue stone, Roman vitriol*, and *Blue vitriol*, and may be prepared by exposing pure copper in thin sheets to the joint action of dilute sulphuric acid and air; or by treating freshly precipitated oxide of copper with diluted pure oil of vitriol; or by boiling the metal with oil of vitriol, either in the concentrated state or diluted with an equal bulk of water. These are the simplest ways of obtaining this salt, which may be reduced to a crystalline form by evaporation. The crystals assume a well-defined rhomboidal form of a fine sapphire-blue color.

121. To make Solutions for Dyeing. In making solutions of copperas, blue stone, chrome, &c., there is no fixed rule to be followed. A quantity of the crystals are put into a vessel, and boiling water poured upon them and stirred until dissolved. Some salts require less water than others when saturated solutions are wanted; but in the dye-house saturation is not essential, and therefore there is always used ample water to dissolve the salt. In all cases, however, the proportions are known, so that the operator, when adding a gallon, or any other quantity of liquor to the dye-bath, knows how much salt that portion contains. From ¼ to 1 pound per gallon is a common quantity.

122. To Prepare Cotton Yarn for Dyeing. Cotton yarn, when spun, is put up in *hanks*, a certain number of which combined constitute a *head;* the number of hanks ranging from 6 to 20, according as the fineness of the yarn varies from very coarse to very fine. Sufficient of these *heads* are tied together, or *banded* with stout twine into a bundle, to make 10 pounds.

After banding, the cotton is boiled in water for 2 or 3 hours until thoroughly wet. The bundles are then loosed, and each roll of yarn is put on a wooden pin, about 3 feet long and 1½ inches thick, 4 or 6 pins making a bundle. The yarn is now ready for dyeing dark colors; but for light shades, it must be bleached previous to dyeing. The bleaching is performed thus:

123. To Bleach Cotton Yarn. A vessel sufficiently large to allow of the yarn being worked in it freely without pressing, is to be two-thirds filled with boiling water; add 1 pint bleaching liquor (*see No.* 104) to every gallon of water in the vessel, and work the yarn in this for half an hour. Into another vessel of similar size, two-thirds filled with cold water, add one wine-glassful sulphuric acid for every 2 gallons water; stir well, and then put the yarn from the bleaching solution into this, and work for 10 minutes; then wash out until all the acid is removed. This will bleach the yarn for dyeing any light shade.

124. To Prepare Cotton Cloth for Dyeing. The cloth is taken out of the fold, and hanked up by the hand, taking the end through the hank and tying it loosely, technically termed *kinching;* it is then steeped over night in old alkaline lye, which loosens and removes the oil, grease and dressing which it has obtained in weaving; it is then thoroughly rinsed in clean water. Where there is a dash-wheel, it should be used for this washing. In consequence of the liquor often fermenting with the paste in the cloth, this process has been technically termed the *rot steep.*

If the cloth is to be dyed a dark color, no further preparation is needed; but if light, the cloth has to be bleached as follows:

125. To Bleach Cotton Cloth. After undergoing the *rot steep,* boil for 3 hours in caustic lye, of the strength of 1 gill of stock lye (*see No.* 101) to the gallon of water; wash out, and steep for 6 hours in a solution of 1 pint of bleaching liquor (*see No.* 104) to the gallon of water; wash, and steep 1 hour in a strong sour of 1 wine-glassful sulphuric acid to 1 gallon water; wash well from this before drying or dyeing.

If the cloth be very heavy, it may be necessary to repeat in their proper order the boiling in lye, the steeping in bleaching liquor, and in the sour, finishing, as before, with thorough washing or drying.

In bleaching cloth for dyeing, care has to be taken that it is all equally white, otherwise it will show in the color.

The quantity of water used should be sufficient to cover the cloth easily without pressure.

If the goods be old, and have previously been dyed, and if the shade required be a deep shade, and the color of the goods light, in that case nothing is generally required but steeping in alkaline lye to remove any grease or starch; but if the color of the cloth is dark, the best method is to bleach as if they were gray goods.

126. To Remove Oil Stains. When there are oil spots upon goods, and so fixed or dried in, that steeping in an alkaline lye will not remove them, rub a little soft soap upon the stain, and let it remain for an hour, then rub gently with the hand in a lather of soap, slightly warmed, and wash in water; for cotton, a little caustic lye will do equally well, but the soap is preferable, and seldom fails. It is essential that all oil or grease be removed before dyeing.

127. To Remove Iron Stains. Take a little hydrochloric acid in a basin or saucer, and make it slightly warm, then dip the iron stain into the acid for about 1 minute, which will dissolve the oxide of iron; the cloth must be well washed from this, first in water, then in a little soda and water, so as to remove all trace of acid. A little oxalic acid may be used instead of hydrochloric, but more time is required, and with old fixed spots is not so effective. The same precautions are necessary in washing out the acid, as oxalic acid dried in the cloth injures it.

128. To Remove Mildew from Cotton. Proceed with the stains by rubbing in soap or steeping in a little soda, washing, and then steeping in bleaching liquor (*see No.* 104), or by putting a wine-glassful of the stock liquor (*see No.* 101) in 1 pint of water; afterwards wash, pass through a sour (*see No.* 105), and wash again.

129. To Remove Indelible-Ink Marks. Steep in a little chlorine water or a weak solution of bleaching liquor (*see No.* 104), for about half an hour, then wash in ammonia water, which will obliterate the stain; then wash in clear water. They may also be removed by spreading the cloth with the ink marks over a basin filled with hot water; then moisten the ink marks with tincture of iodine, and immediately after take a feather and moisten the parts stained by the iodine with a solution of hyposulphate of soda, or caustic potassa or soda, until the color is removed; then let the cloth dip in the hot water; after a while wash well and dry.

130. Indigo Blue Dye for Yarn. The vats used for dyeing indigo blue are usually wine pipes or other large casks, sunk in the ground to a depth convenient for the operators to work at. Five of these constitute a set, and are worked together and kept of the same strength. The yarn being worked in quantities of 100 pounds, 20 pounds are passed through each vat.

Each vat is filled about three-fourths with cold water; there are then added 8 pounds of indigo, 16 pounds of sulphate of iron (copperas), and 24 pounds newly-slaked lime. The whole is well stirred with a rake for half an hour, and this stirring is repeated every 1½ hours for the first day.

The time to stop the stirring is known by the solution becoming a rich oak yellow, having large blue veins running through it and a fine indigo froth on the surface. When these signs are all favorable, the solution is allowed to stand for several hours till all the solid matter settles, when it is ready for use.

The mode of dyeing consists in simply immersing the goods, and working them in the solution for 15 minutes, taking out and wringing or pressing, and then exposing to the air; repeating this operation until the desired depth of color is obtained. The yarn is then washed in cold water and dried. When the shade required is very deep, the yarn may, previous to washing, be passed through a tub of water acidulated with vitriol till it tastes acid, and then washed; this adds brilliancy to the color.

131. Sky Blue Dye for Cotton Goods. To dye 10 pounds of cotton, first bleach the cotton (*see No.* 125); then, to a tub of cold water sufficient to work the goods easily, add ½ pint nitrate of iron, and work in this for 20 minutes; wring out, and pass through a tub of clean water. Into another tub of cold water add 4 ounces ferrocyanide of potassium in solution, and about a wine-glassful of sulphuric acid; work the goods in this for 15 minutes; wring out and wash through cold water, in which is dissolved 1 ounce of alum; wring out and dry. For lighter or darker shades of blue, use less or more of the iron and ferrocyanide; or, should the color be too light after passing through the process described, add 1 ounce more ferrocyanide, repeat the operation through the same tubs, and the shade will be deepened nearly double.

132. Napoleon Blue. For 10 pounds cotton goods, the cotton must be first bleached. Into a tub of cold water put 1 imperial pint of nitrate of iron and 2 gills hydrochloric acid, then add 3 ounces crystals of tin (or 1 pint chloride of tin); stir well and immediately work the goods in it for 30 minutes; wring out and put directly into the *prussiate tub,* made up with water into which is put a solution of 12 ounces ferrocyanide, and one wine-glassful of hydrochloric acid; work in this for 15 minutes, then wash out in clean water in which is dissolved 2 ounces of alum. If a deeper shade of blue is required, wash them in clean water without the alum, pass them again through the two tubs; and, lastly, wash them in water with the alum.

133. Royal Blue. This is dyed in the same manner as *Napoleon Blue,* but the liquors are stronger—using 2 pints iron solution, 2 gills hydrochloric acid, and 4 ounces tin crystals. The Prussiate tub is made up by dissolving in it 1 pound ferrocyanide of potassium, and adding 1 wine-glassful of sulphuric acid, and 1 of hydrochloric acid. If not dark enough with putting through once, repeat.

134. Blue. Copperas (sulphate of iron) is used as a mordant for dyeing blue by ferrocyanide of potassium (prussiate of potassium). The copperas best suited for the blue vat should be of a dark rusty green color, and free from copper, zinc, or alumina. Thus, 10 pounds cotton may be dyed a good rich blue by working it for 15 minutes in a solution of 4 pounds copperas; wring out; and then work through a solution of 4 ounces of the ferrocyanide; finally, wash in cold water containing 1 ounce alum in solution.

Copperas is also used as a dye by the oxidation of the iron within the fibre. Thus:

135. Iron Buff or Nankeen. Take 2 pounds copperas, and dissolve in warm water, then add the requisite quantity of water for working the goods; work in this for 20 minutes; wring out, and put immediately into another vessel filled with lime-water, and work in this for 15 minutes; wring out and expose to the air for half an hour, when the goods will assume a buff color. If the color is not sufficiently deep, the operation may be repeated, working through the same copperas solution, but using fresh lime-water each time. The goods should be finally washed through clean warm water and dried.

136. Nankeen or Buff Dye for Cotton Goods. To a tub of hot water add 1 pint nitrate of iron, and work in this for half an hour 10 pounds cotton previously bleached (*see No.* 125); wash out in water, and dry. This process is simple and easy, and produces a permanent dye.

137. General Receipts for Dyeing Cotton. In the following receipts, the quantities are given for 10 pounds cotton, whether yarn or cloth. For more or less cotton, the quantities can be increased or diminished in proportion; but when small articles are to be dyed—such as ribbons, gloves, &c.—a little more of the materials may be used in proportion to advantage. Where washing is referred to, it is always in cold water, unless otherwise specified.

138. Common Black. Steep the goods in a decoction of 3 pounds sumach while it is hot, and let them lie over night; wring out and work them for 10 minutes through lime-water, then work for half an hour in a solution of 2 pounds copperas. They may either be washed from this, or worked again through lime-water for 10 minutes; then work them for half an hour in a warm decoction of 3 pounds logwood, adding ¼ pint chamber lye; before entering the goods, lift and raise with 2 ounces copperas in solution; work 10 minutes, then wash and dry.

139. Jet Black. The goods are dyed in the same manner as the last receipt; but along with the logwood is added 1 pound fustic.

In both the above receipts if 3 pints iron liquor (*see No.* 118) be used instead of the copperas, or in part mixed with the copperas, it makes a richer shade of black, but copperas is generally used; if mixed, use half the quantity of each.

140. Blue Black. Dye the goods first a good shade of blue by the vat (*see No.* 130), and then proceed as for common black. If the blue be very deep, then half the quantity of the materials for dyeing black will suffice.

141. Spirit Yellow. Work through a solution of protochloride of tin, of the specific gravity of 1° Baumé, for 30 minutes; wash out, and work for 15 minutes in a decoction of 3 pounds bark kept at a boiling heat; lift out the goods and add to the bark solution ½ pint single chloride of tin; work the goods for 20 minutes in this, and then wash well in cold water. This gives a rich yellow.

142. Spirit Brown. First dye the goods a spirit yellow, according to the last receipt; after washing, work for ½ hour in a decoction of 2 pounds lima or peachwood and 1 pound logwood; lift the goods out and add 3 ounces alum in solution, and work the goods in it 15 minutes; wash and dry. By varying the proportions of logwood and limawood, a variety of shades may be produced.

143. Mordant Brown. Steep the goods for six hours in a decoction of sumach, next dye a spirit yellow, according to the receipt given above. Then work for half an hour through a decoction of 2 pounds limawood and 8 ounces logwood; lift the goods, and add 2 ounces alum in solution; work for 15 minutes, wash and dry. This method is well adapted for cotton goods, is better than the spirits, and more easily performed by the non-practical man. The spirit brown is best for yarn.

144. Cinnamon Brown. Dye a dark spirit yellow (*see No.* 141), and work for 30 minutes in 3½ pounds limawood and ½ pound logwood; lift the goods and add 2 ounces alum in solution; wash and dry.

145. Uvanterin Brown. Dye a spirit yellow (*see No.* 141), then work for 20 minutes in a decoction of 1 pound limawood and 1 pound fustic; lift, and add ½ pint red liquor (*see No.* 100); work 10 minutes in this; wash and dry.

146. Fawn Brown. Take 1 part annotto liquor (*see No.* 95), and 1 part boiling water; stir well, and work the goods in it for 10 minutes; wring out and wash in two waters; then work for 20 minutes in a decoction of 2 pounds fustic and 1 pound sumach; lift, and add 3 ounces copperas in solution; stir well, and work for 20 minutes longer; then work for 20 minutes in a decoction of 8 ounces limawood, 8 ounces fustic, and 4 ounces logwood; lift, and add 1 ounce alum; work in this for 10 minutes; wring out and dry.

147. Catechu Brown. Work the goods at a boiling heat for 2 hours in 2 pounds of catechu prepared according to No. 96; wring out, and then work for half an hour in a hot solution of 6 ounces bichromate of potassa; wash from this in hot water. If a little soap be added to the wash water, the color is improved. Deeper shades of brown may be dyed by repeating the operation.

148. Catechu Chocolates. Dye brown according to the last receipt, then work for 15 minutes in a decoction of 1½ pounds logwood; lift, and add 3 ounces alum in solution; work 10 minutes longer; wash out and dry. Different shades of brown and chocolate can be produced, by varying the proportion of logwood, and the strength of the brown dye.

149. Chocolate, or French Brown. Dye a spirit yellow according to receipt No. 141; then work for half an hour in a decoction of 3 pounds logwood; lift, and add ½ pint of red liquor (*see No.* 100), and work 10 minutes longer; wash and dry. A deeper shade may be obtained by adding 1 pound fustic to the logwood.

150. Catechu Fawns. Work the goods 15 minutes in hot water containing 2 pints catechu, prepared as in receipt No. 96; wring out, and work 15 minutes in hot water containing 1 ounce bichromate of potassa in solution; wash and dry.

151. Catechu Fawns—Another Method. Work in the catechu the same as in the last receipt; wring out, and work for 15 minutes in warm water containing 2 ounces acetate of lead in solution; wash in cold water and dry.

152. Catechu Fawns—Another Method. Work in warm water containing 4 pints catechu (*see No.* 95), lift, and add 2 ounces copperas in solution, and work for 15 minutes; wash in water, and then in another tub of warm water in which sufficient soap has been dissolved to raise a lather, and then dry.

153. Common Red. Make a decoction of 3 pounds sumach, and put the goods in at once; let them steep over night; wring out and work for an hour in a mixture of 1 gill red spirits (*see No.* 108), to every gallon water; wring out and wash well; then work for half an hour in a decoction of 3 pounds limawood and 1 pound fustic, using this decoction as hot as the hand can bear it; lift, and add 1 gill red spirits, then work for 15 minutes more; wash out and dry.

154. Barwood Red. To a decoction of 2 pounds sumach, add a wine-glassful of vitriol, and steep the goods in it for 6 hours; wring out and work for an hour in red spirit (*see No.* 103), diluted to 2° Baumé; wring out and wash, then pass through a tub of warm water; put 10 pounds barwood into a boiler with water and bring it near to the boil, then put in the goods and work among the wood grains for ½ hour; lift out, wash, wring and dry. Deeper shades may be dyed by using larger quantities of the materials in each operation.

155. Scarlet. For 1 pound of goods, boil 1½ ounces cream of tartar in water in a block-tin vessel; add 1½ ounces tin spirits, made according to the first receipt in No. 113; boil for 3 minutes, then boil the goods in it for 2 hours; drain and let the goods cool. Next boil ½ ounce cream of tartar for a few minutes in some water; add to it 1 ounce powdered cochineal, boil for 5 minutes, adding gradually 1 ounce tin spirits, stirring well all the time; then put in the goods and dye immediately.

156. Common Crimson. Steep over night in a decoction of 3 pounds sumach; work in spirits diluted 2° Baumé, wash and then work for 30 minutes in a decoction of 3 pounds limawood and 1 pound logwood; lift, and add a gill of red spirits (*see No.* 108); work for 15 minutes; wash and dry. A beautiful red crimson is obtained by omitting the logwood; and a diversity of tints dyed by varying the proportions of the limawood and logwood.

157. Light Straw. To a tub of cold water add 4 ounces acetate of lead in solution, work the goods in this for 15 minutes, and wring out; then work for 10 minutes in another tub of water containing 2 ounces bichromate of potassa; wring out, and work again in the lead solution for 10 minutes; wash and dry.

158. Leghorn. This tint is dyed in the same manner as the last, but adding ½ pint of annotto liquor (*see No.* 95) to the chrome solution. Different shades may be obtained by using more or less of these stuffs, without varying the mode of working.

159. Annotto Orange. Heat the annotto solution (*see No.* 95) to about 140° Fahr.; work the goods in it for 20 minutes; wring out thoroughly in order to economize the liquor, wash in a couple of waters and dry. If the goods are then passed through water with sufficient acid to taste sour, a very red orange, almost scarlet, is obtained, but the tint fades quickly.

160. Logwood Blue. Dye first a light blue with the vat (*see No.* 130), then soak the goods for several hours in a hot decoction of 2 pounds sumach; then work for 15 minutes in water containing 1 pint red liquor (*see No.* 100) and 1 pint iron liquor (*see No.* 118); wash in two waters, hot; then work for 20 minutes in a decoction of 2 pounds logwood; lift, and add ½ pint red liquor, and work again for 10 minutes; wash and dry.

161. Fustic Green on Yarn. Dye a blue with the vat (*see No.* 130), wash and wring, and then pass through red liquor (*see No.* 100) diluted to 4° Baumé; wash through a tub of hot water, and then work for 20 minutes in a decoction of 4 pounds fustic; lift, and add 2 ounces alum in solution; work for 15 minutes, wash and dry.

162. Fustic Green on Cloth. Work the goods in red liquor (*see No.* 100) diluted to 4° Baumé, and dry in a hot chamber; then wet in hot water and work for 20 minutes in a decoction of 3 pounds fustic; lift, and add 2 ounces alum in solution; work again for 15 minutes; wring out and work in *chemic* (a solution of sulphate of indigo whose acid has been neutralized with carbonate of soda); wring out and dry.

163. Dark Green on Cloth. After the goods have been cleaned, work them for 10 minutes in red liquor (*see No.* 100) at 5° Baumé; wring out, and pass through a tub of hot water; then work for half an hour in a decoction of 3 pounds bark; lift, and add ½ pint red liquor (*see No.* 100); work 10 minutes longer, then lift and drain; work next for 20 minutes in a tub of cold water containing 5 gallons chemic (*see last receipt*); wring out and dry. The depth of shade can be varied by increasing or diminishing the quantities of material in proportion.

164. Green with Prussian Blue. Dye a good Prussian blue (*see No.* 131) according to the depth of green required; then work 10 minutes in red liquor (*see No.* 100) at 4° Baumé; wash in warm water, and work for half an hour in a decoction of 3 pounds fustic; lift, and add 2 ounces alum in solution; work again for 10 minutes, wash and dry. A finer tint can be obtained by using bark instead of fustic, but it must not be worked too warm.

165. Sage Green. Dye a Prussian blue (*see No.* 131), and work 10 minutes in a solution of 2 pounds of alum; wring out, and work 15 minutes in a decoction of 1 pound fustic; lift, and add a pint of the alum solution already used; work 10 minutes; wash and dry.

166. Olive or Bottle Green. Dye a good shade of Prussian blue (*see No.* 131); then mordant 10 minutes in red liquor (*see No.* 100) at 5° Baumé; wring out and wash in hot water; then work half an hour in a decoction of 3 pounds fustic and 1 pound sumach, then add ½ pint of iron liquor (*see No.* 118), and work 15 minutes; wash in a tub containing 2 ounces alum, and dry.

167. Olive or Bottle Green—Another Method. Work the goods in red liquor (*see No.* 100) at 5° Baumé, wash out in warm water; then work for half an hour in a decoction of 3 pounds bark and 1 pound sumach; lift, and add ½ pint iron liquor (*see No.* 118), and work 15 minutes; wring out and work 15 minutes in the chemic (*see No.* 162); wring out and dry.

168. Olive Green. Dye a Prussian blue (*see No.* 131); then work for 10 minutes in red liquor (*see No.* 100) at 4° Baumé; wash in hot water, and work in a decoction of 3 pounds bark and 1 pound logwood; lift, and add ½ pint red liquor, and work 10 minutes; wash and dry. By varying the proportions of bark and logwood, different shades of green may be obtained.

If the goods be yarn, a light blue may be dyed by the vat (*see No.* 130) instead of the Prussian blue, and proceeded with as above.

169. Lilac or Puce. Work for an hour in red spirits (*see No.* 108) at 1½° Baumé; wring out and wash; then work half an hour in a decoction of 3 pounds logwood at about 140° Fahr.; lift, and add 1 gill red spirits, and work 20 minutes; wash and dry. Half a pint red liquor (*see No.* 100) or 2 ounces alum, may be added to the logwood after lifting, instead of the red spirit.

170. Lilac or Puce. Work for 15 minutes in red liquor (*see No.* 100) at 5° Baumé; wring out and wash in a tub of warm water; then work half an hour in a decoction of 2 pounds logwood at 140° Fahr.; lift, and add ½ pint red liquor, or 2 ounces alum; work 10 minutes, and wash in clean warm water; wring out and dry.

171. Light Purple or Adelaide. Steep the goods in a decoction of 2 pounds sumach; wring out, and work half an hour in plumb spirit (*see No.* 111); wring out, and wash in clean cold water until no taste of acid is left on the goods, and dry.

When working with the plumb spirit, it is advisable to put a sufficiency of it into a separate vessel for working the goods, returning the liquor afterwards to the plumb tub.

172. Light Purple. Steep in a decoction of 2 pounds sumach; wring out and work for 20 minutes in red spirits (*see No.* 108) at 1½° Baumé; wash well and then work in plumb spirit, and finish the same as the last receipt.

173. Purple. Steep in a decoction of 2 pounds sumach until cool; work in red spirits (*see No.* 108) at 1½° Baumé for an hour, and wash in cold water; then work for half an hour in a decoction of 3 pounds logwood at 140° Fahr.; lift, and add 1 gill red spirits, and work 10 minutes more; wash in cold water and dry.

If a browner tint is required, use a little more sumach; for a bluer tint, use less sumach and more logwood; and add, after lifting, ½ pint red liquor (*see No.* 100), or 2 ounces alum, instead of red spirits.

174. Lavender or Peach. Work for 20 minutes in plumb spirit (*see No.* 111); wring out, and wash in clean cold water till free from acid taste, and dry.

175. Logwood, Lilac or Puce. Dye a good shade of Prussian blue (*see No.* 131); then work 15 minutes in a decoction of 1 pound logwood at 140° Fahr.; lift, and add 4 ounces alum; work 10 minutes, then wash in cold water and dry.

176. Logwood Lilac. Dye a sky blue (*see No.* 131); then work for 15 minutes in a tub of warm water containing 1 gallon alum plumb (*see No.* 114); wring out and dry.

177. Common Drab. Work for 15 minutes in a decoction of ½ a pound sumach; lift, and add 1 ounce copperas in solution, and work 15 minutes more; wash out in a tub of cold water, then work 15 minutes in a decoction of 4 ounces fustic, 2 ounces limawood, and 1 ounce logwood; lift, and add 1 ounce alum in solution; work 10 minutes, then wring out and dry.

A great variety of different tints can be produced by varying the proportion of the limawood, fustic, and logwood; and lighter or darker shades by diminishing or increasing the quantities of sumach and copperas.

178. Olive Drab. Work for 15 minutes in ½ pound sumach; lift, and add 1 ounce copperas, and work 15 minutes more; wash in water, then work for 20 minutes in water with ½ pound fustic; lift, and add 1 ounce alum, and work for 10 minutes and dry.

179. Drab. To a tub of hot water add 1 pint annotto preparation (*see No.* 95), which gives a light salmon color; then proceed as for *olive drab* in last receipt. By varying the quantities a great variety of tints may be obtained.

180. Stone Color. Work the goods 20 minutes in a decoction of 1 pound sumach; lift, and add 1 ounce copperas in solution; work for 15 minutes, and wash in cold water; then work 10 minutes in warm water containing ½ pint alum plumb (*see No.* 114); wring out and dry. This gives a reddish tint, which may be avoided by using a solution of ½ ounce of alum instead of the alum plumb.

181. Catechu Stone Drab. Work the goods 15 minutes in hot water containing 2 pints prepared catechu (*see No.* 96); lift, and add 2 ounces copperas in solution; work for 15 minutes, and wash in water, then work for 10 minutes in a tub of warm water containing a decoction of 2 ounces logwood; lift, and add ½ ounce alum; work 10 minutes more, wring out and dry.

182. Catechu Drab. Work for 15 minutes in hot water containing 1 pint prepared catechu (*see No.* 96); lift, and add 1 ounce copperas; work 10 minutes; wash out and dry. A variety of tints may be obtained by finishing in a weak decoction of one or other of the different dye-woods.

183. Chrome Dyes for Cotton Goods. The following recipes will serve to illustrate the use and value of chrome (bichromate of potassa) as a dyeing agent. The quantities given are for dyeing 10 pounds weight of cotton, and may be increased or diminished in proportion, according to the quantity of goods to be dyed.

184. Light Straw. To a tub of cold water add 4 ounces acetate of lead, previously dissolved; work the goods through this for 15 minutes, and wring out; into another tub of water add 2 ounces bichromate of potassa; work the goods through this 10 minutes, wring out and pass again through the lead solution for 10 minutes; wash and dry.

185. Lemon Color. Into a tub of cold water put 1 pound acetate of lead, previously dissolved; work the goods in this for 15 minutes, and wring out; into another tub of cold water put 6 ounces bichromate of potassa in solution; work the goods for 15 minutes through this, and wring out; then work it 10 minutes in the lead solution; wring out, wash, and dry.

186. Deep Yellow. To a tub of cold water add 1 pound acetate of lead, and 1 pound nitrate of lead in solution; work the goods in this for 30 minutes, and wring out; then to a tub of warm water add 12 ounces bichromate of potassa, and work the goods in it for 15 minutes; expose to the air for half an hour, then pass again through both solutions, working them the same time in each as before, and expose to the air for one hour; then pass them through the lead solution; wring out, wash and dry. If the color is not deep enough they may be passed through the solutions again, observing the same rules.

187. Deep Amber Yellow. Put into a tub of water 1 pound acetate of lead, and to this add gradually caustic potassa or soda, until the precipitate formed be re-dissolved, taking care not to add more alkali than is required for this solution; work the goods in this for 30 minutes; wring out, and work for 15 minutes in another tub of water to which 8 ounces bichromate of potassa has been added in solution; wring out, wash and dry. 2 or 3 ounces sulphate of zinc may be added to the chrome solution with good effect. If a deep red amber be required, add to the chrome solution ½ pint muriatic acid.

188. Chrome Green. Dye a blue by the process described in No. 131; then dye a yellow according to the last receipt. The depth of the blue and yellow will regulate the tint of green.

The principal difficulty is when a particular depth or shade of green is wanted, to ascertain the exact shade of blue to be given, as blue cannot be added upon the yellow. This is a matter which can only be learned by practice.

189. French Process for Dyeing Turkey-Red. The following process for dyeing turkey-red, is the one in general use in France at present.

The quantities of materials, &c., given, are for dyeing 2200 pounds of cotton, which has already, it is assumed, been subjected to thorough washing and scouring in soap.

Dissolve 20 to 22 pounds carbonate of potassa in about 330 gallons of water, and provide for future use 1300 to 1400 pounds of fat oil; next divide the goods to be dyed into three equal portions.

The first step in the process is *oiling* the goods; mix together one-third part of the fat oil and of the solution of potassa, stirring by degrees into the oil sufficient solution to produce an emulsion; this makes the *white liquor*.

One-third of the goods are padded, that is, drawn through evenly backwards and forwards, in this white liquor; then take them out and lay together in a heap in a fresh cool place for 10 or 12 hours, and dry in an atmosphere heated to 140° Fahr.

While the first portion of the goods is drying, prepare a second portion of white liquor, and subject a second portion of the goods to the same operation as the first; the remaining portion of the goods is in turn subjected to the same treatment, using the remainder of the fat oil for a third tub of white liquor; by this means the process proceeds without intermission, each portion being under different stages of treatment simultaneously.

This routine is repeated several times (generally seven or eight) on each portion, each always in its own tub, according to the quantity of oil which it is desired to fix on the goods. If the bath begins to fail, either a little tepid water is added, or a certain quantity of *old white liquor* proceeding from the washings.

The next stage is to remove superfluous oil; this is done by macerating the goods twice, successively, for 24 hours each time, in a solution of carbonate of potassa at 1° Baumé. The liquid which is wrung or pressed out of them constitutes the *old white liquor*, which may be employed again for filling up in the oiling operation. The goods are then carefully rinsed.

The third process is *galling* or *mordanting*. Bruise 22 pounds gall-nuts, and boil repeatedly until thoroughly drawn; add sufficient water to make up to 66 gallons; dissolve in this 35 pounds alum with the assistance of heat. This is sufficient for working one-half, that is, 1100 pounds of the cotton, which must be padded in the liquid at a temperature of about 160° Fahr.; it is next suspended for 2 days in a drying-room heated to 112° Fahr., and then passed into a hot concentrated bath of chalk. Care must be taken to work the goods very equally in this bath, in order to avoid streaking. The goods are then washed, and present a fawn-colored appearance.

The fourth step is *the first dyeing*. This is performed on 10 pieces at a time, the proportions of madder varying according to the breadth and length of the pieces, from 13, 15, 17 to 20 pounds madder for each piece. As in the preceding process, the madder is divided into two equal portions, one portion being used for the first dyeing, and the other portion reserved for the second dyeing. The one portion is mixed with the requisite quantity of water, from 300 to 400 gallons; the 10 pieces are introduced into this bath at a tepid heat, and kept in it 3 hours, the temperature being gradually increased, until, at the end of 2½ hours, boiling point is reached; and this heat is sustained for the remaining ½ hour. The goods must then be washed, thoroughly cleansed, rinsed and dried.

The fifth stage is the *second galling;* which is prepared in the same gall liquid, and in the same manner as the *first galling*, finishing with the chalk bath, washing and drying.

The sixth operation is the *second dyeing*, an exact repetition of the *first dyeing*, using the remaining half of the madder reserved for this purpose.

The seventh step, *first clearing*, is performed in a close boiler, two-thirds filled with water containing in solution 13 pounds soap, and 3½ pounds carbonate of potassa; the goods are boiled in this for 8 hours.

The eighth process is a *second clearing*, conducted in the same manner as the *first clearing*, but dissolving in the water 14¼ pounds soap, and 14 ounces chloride of tin instead of the potassa solution.

For only very lively reds a *third clearing*, similar to the second, is required. The goods, after clearing, are exposed for some time in the air; then worked through a bran bath, which adds to the brightness of the color.

The process here described is slightly modified by some French dyers; thus, experience proves that the oil is better fixed in the stuff when the drying is not performed too rapidly; and there are some who, when the season does not admit of exposure to the air, heap the pieces together, after oiling, in a drying-room heated to 95° Fahr., turning them over from time to time to prevent injury from overheating. Some use ox-blood in the proportion of 40 pounds blood to 100 pounds madder.

190. Violet. Dye a turkey red (*see No.* 189), and then pass through the blue vat. (*See No.* 130.)

191. Preparation and Dyeing of Woolens. To prepare new woolen goods for dyeing, the cloth or yarn (if the latter, it is first banded with twine into spindles, *see No.* 122,) is steeped over night in soap lye, and then scoured through clean soap to remove all oil or grease that may be upon the wool. Instead of soap, a scouring mixture may be prepared with 1 pound soft soap and 1 pound common soda (or ½ pound soda-ash), in 10 gallons water.

Goods to be re-dyed must first be steeped and scoured in soap and soda. If the remaining color be unequal or dark, the goods must be worked for a short time in a sour, made by dissolving 2 ounces bisulphate of potassa in each gallon of water used. Woolen goods are always dyed hot, as near boiling point as possible; this necessitates the use of boilers, which should be of copper, or copper and tin, as iron will not answer the purpose. The dye-stuffs are generally put in the boiler, and the goods worked with it, but it is cleaner to make decoctions (*see No.* 94), and use the clear liquor. All washings are to be in cold water unless otherwise specified. The quantities given in the following receipts are for dyeing 10 pounds of woolen goods, either cloth or yarn, unless otherwise specified.

192. Black. Work for 20 minutes in a bath with 8 ounces camwood; lift, and add 8 ounces copperas; work 20 minutes more, then withdraw the fire from the boiler, and submerge the goods in the liquor over night, then wash out. Work for an hour in another bath containing a decoction of 5 pounds logwood and 1 pint chamber lye; lift, and add 4 ounces copperas; work for 30 minutes longer, wash and dry.

193. Brown. Work for an hour in a bath made up with 2 pounds fustic, 2 pounds madder, 1 pound peachwood, and 4 ounces of logwood; lift, and add 2 ounces copperas; work for 30 minutes, wash and dry.

194. Brown Dye. The different shades of this dye vary from pale yellow and reddish brown up to very dark brown, almost black, every shade of which, however, may be produced, as the taste of the workman may dictate, by mixtures of reds and yellows with blues and blacks, or by simple dyes, which at once impart a brown,—as catechu, walnut rinds, or oxide of manganese.

Boil the cloth in a mordant of alum and common salt dissolved in water, then dye it in a bath of logwood, to which a little green copperas has been added. The proportion of alum should be 2 ounces, and of salt 1 ounce, to every pound of cloth.

Or boil the goods in a mordant of alum and sulphate of iron, then rinse them through a bath of madder. The tint depends on the relative proportions of the alum and copperas; the more of the latter, the darker will be the dye. The joint weight of the two should not exceed ⅙ of the weight of the wool. The best proportions are 2 parts of alum and 3 of copperas.

For other receipts for dyeing black and brown see Index.

195. Crimson. Work in a bath for one hour with 1 pound cochineal paste, 6 ounces dry cochineal, 1 pound tartar, and 1 pint protochloride (single chloride) of tin; wash out and dry.

196. Scarlet. Work for an hour in a bath with 1 pound tartar, 2 ounces dry cochineal, 8 ounces sumach and 8 ounces fustic; wash out and dry.

197. Red. Work for 30 minutes in a bath made up with 1 ounce chrome and 1 ounce alum; wash in cold water; then work for 30 minutes in another bath with three pounds peachwood or limawood; lift, and add 1 ounce alum; work for 20 minutes; wash and dry.

198. Claret Red. Work for an hour in 5 ounces camwood; lift, and expose the goods until well drained and cold; meanwhile, add to the camwood bath 4 ounces copperas, 2 ounces alum, and 8 ounces logwood; work the goods for 30 minutes, wash and dry.

199. Scarlet. For every 100 pounds of fabric, boil, in a suitable kettle, 11 pounds ground Honduras cochineal, 5 pounds half-refined tartar or 3 pounds tartaric acid, 2 pounds oxalic acid, 1 pound tin crystals, 1½ pounds flavine, 10 pounds scarlet spirit (*see below*). After it has boiled for about fifteen minutes, cool the dye to 180° Fah., enter the goods, handle then quickly at first, and let them boil slowly for 1 hour, when they will be a good scarlet. Take them out, cool, and rinse in cold water. If it should happen that the wool or flannel shows some white hair, which is generally the case when new wool is used, then add 5 pounds of raw muriatic acid to the dye. This powerful agent will work wonders in scarlets, oranges, and pinks, as it tans the wool, which is perhaps a little greasy, and prevents the tin crystals from fastening too quickly to it, and thereby evener colors are obtained. This latter fact is very valuable, and not generally known.

Scarlet spirit is thus prepared: Take 16 pounds muriatic acid 22° Baumé, 1 pound feathered tin, 2 pounds water. The acid should be put in a stoneware pot, and the tin added, and allowed to dissolve; the mixture should be kept a few days before using.

200. Lac Scarlet. Work for 30 minutes in a bath with 1 pound tartar, 8 ounces sumach, and 2 pounds lac; lift, and add about a gill of bichloride of tin; work for 30 minutes, wash and dry.

201. Pink. Work for an hour in a bath made up with 1 pound tartar, 6 ounces alum, 1 pound cochineal paste, and 1 gill red spirits (*see No.* 108); wash in cold water and dry.

202. Yellow. Work for 20 minutes in a bath of water containing 8 ounces tartar and 8 ounces alum; lift, and add 2 pounds bark, 8 ounces sumach, 8 ounces fustic, and 1 pint red spirits (*see No.* 108); work in this for 40 minutes, wash out and dry.

203. Orange. Work for 40 minutes in 2 pounds sumach, 3 ounces dry cochineal, 1 pound fustic, 8 ounces tartar, and 1 pint red spirits (*see No.* 108); wash and dry.

204. Sky Blue. Work for 30 minutes in a bath containing 8 ounces argol, 1 pound alum, and 1 gill indigo extract (*see No.* 99); wash out and dry. The shade of blue will depend on the quantity of indigo extract used.

For other shades of blue see Index.

205. Pigeon Blue. Work for 40 minutes in 2 ounces chrome (bichromate of potash), 4 ounces alum, and 1 ounce tartar; wash out in cold water, and then work for 30 minutes in another bath made up with 3 pounds logwood; lift, and add 1 ounce verdigris; work for 15 minutes, wash and dry.

206. Apple Green. Work for 30 minutes in a bath with one ounce chrome and 1 ounce alum; wash through cold water, then work for 30 minutes in another bath with 2 pounds fustic and 8 ounces logwood; wash and dry. Different proportions of the materials used will produce different shades.

207. Green. Work for 15 minutes in 5 pounds fustic, 2 ounces argol, and 5 ounces alum; lift, and add ½ gill of indigo extract (*see No.* 99); work for 30 minutes and dry. More or less indigo extract will make the green bluer or yellower, as required.

208. Fast Green. First dye a blue in the indigo vat (*see No.* 130) according to the depth of the green required; then work for an hour in a bath with 4 pounds fustic and 2 pounds alum; dry out.

209. Olive. Work for an hour in a bath made up with 10 ounces fustic, 8 ounces logwood, 4 ounces madder, and 2 ounces peachwood; lift, and add 4 ounces copperas in solution; work for 30 minutes and dry.

210. Wine Color. Work for an hour in a bath with 4 pounds cudbear, and dry. For a darker shade use more cudbear. If the tint be desired bluer, add, after 30 minutes working, 1 gill ammonia; if a redder tint is wanted, add a wine-glassful of hydrochloric acid; but if this last be used, the goods must be washed out before drying.

211. Light Violet. Work for an hour in a bath with 4 ounces cudbear, 4 ounces logwood, 2 ounces barwood or camwood, and 2 ounces peachwood; lift, and add 2 ounces alum in solution, work for 30 minutes and dry.

212. Lilac or Puce. Work in a bath for one hour with 10 ounces logwood, 1 ounce camwood and 8 pounds cudbear; lift, and add 2 ounces copperas in solution; work for half an hour and dry.

213. Brown Drab. Work for 30 minutes in a bath with 2 ounces ground madder, 1 ounce peachwood, 2 ounces logwood, and 6 ounces fustic; lift, and add 3 ounces copperas in solution; mix well and work the goods for 30 minutes more; then wash and dry. The shade can be adjusted to suit, varying the quantities and proportions of the dyewoods.

214. Properties of Dye-woods. Peachwood reddens, madder gives the drab tint, fustic supplies yellowness, and logwood induces a slate hue.

215. Stone Drab. Work the goods for 20 minutes in a bath containing 1 ounce peachwood or limawood, 2 ounces logwood and ½ ounce fustic; lift, and add 1 ounce copperas in solution; stir well and work in this for 30 minutes; lift out and expose to the air for a short time; wash and dry. Different shades are made by varying the quantities of the dye-woods. (*See last receipt.*)

216. Slate. Work for half an hour in a bath with 8 ounces logwood and 1 ounce fustic; lift, and add 1 ounce alum and ½ ounce copperas in solution; work for half an hour; wash and dry. For a bluer tint, use less alum and more copperas; for more purple, use less fustic and more alum, &c.

217. Blue. Dyeing woolens blue is performed by dipping in the blue vat (*see No.* 130), and then exposing to the air, repeating the operation till the desired depth of color is obtained.

218. Blue Purple. 100 pounds wool are first dipped a light blue in the vat, and well rinsed. Then take a stone pot, put in 3 pounds tartar, 3 pounds feathered tin, 5 pounds blue vitriol, and 20 pounds muriatic acid; heat all in a sand bath until dissolved.

From this mordant take 10 pounds in a suitable kettle; add 5 pounds tartar to it, stir it well, and enter the wool at 170° Fahr.; let it boil for 1 hour, take it out, cool, and let it lay for 24 hours. Then boil out 20 pounds good logwood for ¾ hour in fresh water; cool off the kettle to 150° Fahr., enter the wool, and handle it well for an hour, then heat it up to 185° Fahr., but do not let it boil; let it go for 1 hour more, when it will be a dark purple. This color stands the sun remarkably well, perhaps owing to the fact that there is not any alum or sulphuric acid used, except that contained in the blue vitriol.

219. Blue Purple, Fast Color. 100 pounds of wool are first dipped in the blue vat to a light shade, then boiled in a solution of 15 pounds alum, and 3 pounds half-refined tartar, for 1½ hours; the wool taken out, cooled, and let stand 24 hours. Then boil in fresh water 8 pounds powdered cochineal for a few minutes; cool the kettle to 170° Fahr.; handle the prepared wool in this for 1 hour, in which time let it boil for ½ hour, when it is ready to cool, rinse, and dry. By coloring first with cochineal, as above, and finishing in the blue vat, the fast purple, or dahlia, so much admired in German broadcloths, will be produced.

220. Royal Blue Dye for Woolen Goods. Woolens may be dyed different shades of blue with nitrate of iron, observing the general rule that woolens must be worked at a boiling heat.

To dye 5 pounds of woolen goods—work for 20 minutes in a bath with 1 pound ferrocyanide of potassium, and lift; then take ½ pint nitrate of iron and add to it 1 ounce crystals of tin (or 1 pint chloride of tin); stir well for a few minutes and then add this mixture to the bath, and work the goods in this for 30 minutes; wash out and dry. For various shades of color, increase or diminish the quantities in proportion.

221. Chrome Dyes for Woolen Goods. The quantities given in the following receipts are for dyeing 5 pounds of woolen goods, unless otherwise stated. It must be understood that the goods must be cleaned before dyeing, and the dyeing must always be performed at a boiling heat.

222. Black. Work for 1 hour in a bath with 8 ounces bichromate of potassa, 6 ounces alum, and 4 ounces fustic; lift, and expose to the air for a short time; wash well, and then work for 1 hour in another bath with 4 pounds logwood, 4 ounces barwood, and 4 ounces fustic; lift, and add 4 ounces copperas in solution; work half an hour in this, and then wash and dry. In order to dye a blue black, the goods must be first dyed blue by the vat (*see No.* 130) or otherwise, and then proceeded with as for black, only using less materials.

223. Brown. Work for half an hour in 8 ounces of bichromate of potassa; lift, and expose till cold; then work an hour in 2 pounds fustic, 4 ounces madder, 3 ounces cudbear, 4 ounces tartar, 2 ounces logwood; lift out and dry; or it may be washed before drying.

224. Rich Yellow Brown. Work for an hour in the following bath: 2 ounces bichromate of potassa, 2 ounces argol, 2 ounces alum; wash from this bath; then work about 40 minutes in another bath made up with 2 pounds fustic, 1 pound madder, 8 ounces peachwood, and 4 ounces logwood; wash out and dry. This gives a very beautiful brown; and a great variety of tints and shades may be made by varying the quantities of the last bath, the first bath remaining the same.

225. Rich Yellow. Work for half an hour in a bath with 3 ounces bichromate of potassa and 2 ounces alum; lift, and expose till well cooled and drained; then work for ½ hour in another bath with 5 pounds fustic; wash out and dry.

226. Bottle Green. Work for an hour in a bath with 2 ounces bichromate of potassa and 4 ounces alum; lift out and expose to the air till cold; then work for an hour in a second bath with 3 pounds fustic, 1½ pounds logwood; wash out and dry.

227. Invisible Green. Work for an hour in a bath with 3 ounces bichromate of potassa, 4 ounces alum; lift, and expose to the air for some time; then work for an hour in a second bath with 2 pounds fustic, 3½ pounds logwood; wash out and dry. By comparing these last two receipts it will be seen that the different shades are produced by varying the proportions of the same dye-stuffs, and will serve as a guide for other shades of dark green.

228. Olive. Work for an hour in a bath with 4 ounces chrome, 2 ounces alum; lift and expose to the air; then work for an hour in a bath with 3 pounds fustic, 1½ pounds camwood, 1 pound logwood; lift out and dry.

229. Purple. Work the goods half an hour in a bath with 1 ounce bichromate of potassa, 1 ounce alum; lift out and wash in cold water; and then work half an hour in a bath with 2 pounds logwood, 1 pound peachwood; lift, and add 1 ounce alum in solution; work in this for 20 minutes; wash and dry. If a lighter and redder shade be required, use less logwood and more peachwood. For a darker shade use more of each.

230. Rich Green Drab. Work the goods 30 minutes in a bath with 1 ounce bichromate of potassa, ½ ounce alum, ½ ounce tartar; lift out and wash in cold water; then work for half an hour in another bath with 4 ounces logwood, 2 ounces fustic, 1 ounce barwood (or ½ ounce peachwood); wash and dry. The shades of this can be varied by using different proportions of the stuffs.

231. Rich Drab. Work for 30 minutes in ½ ounce bichromate of potassa; lift, and add 1 ounce of logwood; work in this for 30 minutes; lift out, wash and dry. Different proportions will produce different shades of color.

232. Chrome Blue. 100 pounds of wool are boiled for one hour in a solution of 3 pounds bichromate of potash, 6 pounds alum, 1 pound half-refined tartar; then it is taken out, cooled, and rinsed. Boil 6 pounds good logwood in a bag for half an hour in fresh water, add 3 pounds cudbear, well moistened and dissolved. Cool the dye to 180° Fahr. Enter the prepared wool, and handle it for ¾ of an hour; bring it to a boil in this time. This color ought to be always left a shade lighter when finished, as all chrome colors darken in drying.

In the foregoing receipts, the quantity of water to be used is not material, but will be regulated according to the size of the vessel and the amount of goods to be dyed, but there should always be enough water to cover the goods without the necessity of pressing them down.

Rules for making decoctions, &c., will be found in No. 94.

233. Preparing and Dyeing Silk. New silk is banded in the same manner as cotton (*see No.* 122), in quantities convenient for making up into skeins when finished. After banding, it is tied up carefully in fine canvas bags and boiled three or four hours in strong soap-water to remove all the gum. Yellow silk must be first worked on sticks for an hour in a solution of soft soap at a temperature of about 200° Fahr., and then boiled in bags. It is then washed from the soap and put on sticks for dyeing.

Silk goods to be re-dyed must be steeped in a strong soap solution at nearly boiling point for a few hours, to remove all stains and grease; they are then washed, and if the color on them is light and equal, and they are to be dyed dark, then no further preparation is required; but if the color is unequal, they must be soaked for 15 minutes in a *sour* (*see No.* 105), and then washed out.

The quantities given in the following receipts are for five pounds of silk. If the goods are tightly spun, such as ribbons, dress silk, &c., the quantities must be slightly increased.

There must be sufficient water used to cover the goods laying loosely. When goods are washed from the dye, it is always to be in cold water, unless otherwise stated.

234. Black. Work for an hour in a solution of 8 ounces copperas; wash well out in cold water; then work in a decoction of 4 pounds logwood, adding to it ¼ pint chamber lye; lift, and add 2 ounces copperas in solution; work 15 minutes, wash and dry.

This gives a good black, but not very deep.

235. Deep Black. Work for an hour in a solution of 8 ounces copperas (sulphate of iron), and 2 fluid ounces nitrate of iron; and, after washing out, work in the decoction of logwood and chamber lye, as in the last receipt, finishing as there directed.

236. Blue Black. If a *blue black* is required, follow the same directions, but add a little white soap, instead of the chamber lye, to the logwood decoction, and add no copperas after lifting.

237. Full Deep Black. Work for 1 hour in a solution of 1 pound copperas and 2 ounces nitrate of iron; wash out, and work for an hour in a decoction of 5 pounds logwood and 1 pound fustic; lift, and add 2 ounces copperas, and work 10 minutes; wash and finish. If the color is not deep enough, add a little more logwood before lifting.

238. French Black. Work for an hour in a solution of 1 pound copperas and 4 ounces alum; wash out well, then work for an hour in a decoction of 4 pounds logwood, with a little white soap added; wash out and finish.

239. Blue Black by Prussiate. Dye a deep Prussian blue according to receipt No. 131, and work, from the prussiate, for half an hour, in 8 ounces copperas; wash well out in cold water, and then work for half an hour in a decoction of 2 pounds logwood; lift, and add a little of the copperas solution first used, then work for 10 minutes more; wash and dry.

240. Deep Hat Black. Work for 15 minutes in a decoction of 2 pounds fustic and 1 pound bark; lift, and add 6 ounces acetate of copper and 6 ounces copperas in solution; work for 15 minutes more; then sink the silk below the surface and let it steep over night; lift out and wash; then, to a decoction of 5 pounds logwood, add white soap sufficient to make a lather, and work the silk in it for an hour; wash out and dry.

241. Brown. Dye an annotto orange (*see No.* 159); then work for 20 minutes in a decoction of 3 pounds fustic, 8 ounces sumach and 8 ounces peachwood; lift, and add 3 ounces copperas in solution, and work for 15 minutes; wash out in two waters, adding ½ pint alum solution in the last water. If the particular tint is not obtained, it may be given in the last alum-wash by adding as follows: for yellowness, a little fustic; for redness, a little peachwood; for depth or blueness, logwood. A number of different tints of brown may be obtained by varying the proportions of fustic, sumach and peachwood. A great many particular hues of brown may be dyed by this method; for instance, by using only fustic and sumach in the second operation, a California brown is obtained, &c. So that any intelligent person may regulate his colors and tints.

242. Red Brown. Dye a deep annotto orange (*see No.* 159); then work for 15 minutes in plumb liquor (*see No.* 111); wash well and dry. Particular tints can be made by adding fustic, peachwood or logwood to the last washing, as described in the last receipt.

243. Red Brown. Steep the silk for an hour in a solution of 8 ounces alum to each gallon water, then wash out in warm water; next, work half an hour in a decoction of 1½ pounds fustic, 1½ pounds peachwood, and 8 ounces logwood; lift, and add 1 pint of the alum solution; work 10 minutes, wash and dry.

244. Chocolate Brown. Steep the silk for an hour in a solution of 1 pound alum to each gallon of water; wash once in warm water, and then work for half an hour in a decoction of 3 pounds peachwood and 1 pound logwood; lift, and add 1 pint of the alum solution, work again for 15 minutes; wash out and dry.

For deeper shades use less peachwood and more logwood; for a still deeper tint, add about 4 ounces fustic.

245. Bronze Brown. Work for half an hour in a decoction of 8 ounces fustic, to which 4 fluid ounces of archil liquor has been added; lift, and add 2 ounces solution of copperas; work 15 minutes, wash and finish.

246. Cochineal Crimson. To every gallon of water used, add about 2 fluid ounces bichloride (oxychloride) of tin, allow any sediment to settle, and warm the clear solution; work the silk in this for an hour or more. Boil 2 pounds cochineal by suspending it in a bag on the surface of some water; add this to a quantity of water sufficient for working the goods, and bring it to a blood heat. Wring the silk from the tin solution and work it in the cochineal solution for ½ hour; then let it steep for several hours well under the liquor; wash out well in cold water. If the shade is not blue enough, add to the water a little cochineal dissolved in ammonia; work in it for 10 minutes, wring out and dry.

247. Common Red. Work the goods for 15 minutes in a decoction of 2 pounds peachwood and 1 pound fustic; lift, and add 4 fluid ounces red spirits (*see No.* 108); work for 15 minutes, wash in cold water and finish.

Different shades are made by varying the proportions, and claret tints are obtained by adding a little logwood. These common dyes are apt to fade.

248. Cochineal Pink. This is dyed in the same manner as cochineal crimson (*see No.* 246), using much less cochineal; about half a pound makes a good pink, and intermediate shades are produced by adjusting the proportion of cochineal.

249. Cochineal Scarlet. First dye a deep annotto orange (*see No.* 159); then dye a cochineal crimson according to No. 246.

250. Mixture for Dyeing Common Reds. Make a strong decoction by boiling 1 pound limawood or brazilwood to each gallon of water. Let the wood settle; decant the liquor, and let it stand to cool for 24 hours; decant the clear liquor and add ½ pint plumb spirits (*see No.* 111) to every gallon of liquor; after standing a few hours it is ready for use.

251. Common Crimson. Put some of the common red mixture (*see No.* 250) into a copper or stoneware vessel, and work the goods in it for ½ an hour; then wash out thoroughly, wring and dry.

252. Common Scarlet. Dye an annotto orange (*see No.* 159), then dye a common crimson according to the last receipt.

253. Ruby, Maroon, &c. Take 1 pound cudbear, and boil in a bag for 15 minutes; and work the silk in this for ½ an hour.

For a *bluish* tint, lift, and add 3 fluid ounces liquid ammonia; work 10 minutes, wring and dry.

For a *red* tint, lift, and instead of the ammonia, add 2 fluid ounces red spirits (*see No.* 108); work 10 minutes, wring and dry.

For a *brownish* hue, make a decoction of 1 pound cudbear and 4 ounces fustic; work for ½ an hour; lift, and add 2 ounces red spirits; work for 10 minutes and finish.

For a *deep violet* hue, proceed as in the last receipt, using 4 ounces logwood instead of the fustic.

254. Sky Blue. To 1 pint sulphate of indigo add 2 or 3 gallons boiling water; steep in this a piece of woolen cloth, such as an old blanket, for a day; take it out and wash in cold water.

If the *sky blue* is required to be light, warm some water in a vessel to about 98° Fahr., steep the woolen cloth in it for a few minutes, and wring out; this will leave sufficient blue in the water to dye the silk; add 1 ounce alum in solution, and work the silk in it for 20 minutes; wring out and dry.

255. Dark Blue. If a *deep blue* be required, blue the water as before with the woolen cloth, add 1 ounce pearlash; then add 1 ounce alum in solution, with a few drops of sulphuric acid; then work the silk in it as before.

Half an ounce of indigo extract (*see No.* 99) may be used for bluing the water, instead of using the woolen cloth for that purpose. The exact quantity of indigo extract depends on the shade of blue required.

256. Sky Blue Dye for Silks. For 5 pounds of silk goods, add to a sufficient quantity of water to work the goods ½ pint of nitrate of iron; work in this for 20 minutes, then wash out in cold water. Into another vessel of cold water add 3 ounces ferrocyanide of potassium in solution, and 1 fluid ounce of strong sulphuric acid; work through this for 10 minutes, then wash in cold water with 1 ounce of alum dissolved in it, and finish.

257. Royal Blue. Into a vessel of cold water add 2 pints nitrate of iron; then take 1 pint water and ½ pint of hydrochloric acid, and add to it 3 ounces crystals of tin; when dissolved, add this (or 1 pint chloride of tin) to the vessel containing the iron; stir well and work the goods in it immediately for half an hour. Into another tub dissolve 8 ounces of the ferrocyanide, and add to it 2 fluid ounces of sulphuric acid; the goods are wrung out of the iron solution, and put directly into this second vessel, and worked for 15 minutes; then wash out in cold water with 2 ounces of alum dissolved in it, and finish. If the shade is not sufficiently deep, before washing them in the alum water, they may be passed through the iron solution, and the ferrocyanide solution, working in each the same time as at first, only adding 2 ounces more ferrocyanide before passing the goods through the second time; then finish as before stated. Deeper shades are obtained by using more iron and tin, or by repeating the dips. Some wash out the iron solution in water before going into the ferrocyanide, and also wash it again in clean water before putting back into the iron; the shade will not be so deep, but there is less risk of an unequal color.

258. Rich Deep Blue Dye for Silk Goods. To dye 5 pounds of silk goods, add to the water required to work the silk, 2 pints chloride of iron and 1 pint *double muriate* or chloride of tin; work in this half an hour; lift, and work in a solution of 8 ounces ferrocyanide of potassium; if the color be not deep enough, repeat the operation through both solutions; then wash out in water in which 2 ounces of alum have been dissolved.

259. Deep Blue Dye for Woolen Goods. To dye 5 pounds woolen goods, add to the requisite quantity of water, 2 pints chloride of iron and 1 pint chloride of tin; work in this for half an hour; lift, and work half an hour in a bath with 4 ounces of the ferrocyanide. If the color is required to be deeper, repeat this through the same stuff, adding 2 ounces more ferrocyanide; then wash out in cold water, and dry.

260. Lavender. Add 1 pint plumb liquor (*see No.* 111) to sufficient water to work the goods easily; stir well and work in this for 20 minutes, then wash in cold water and dry. A darker or lighter tint is obtained by using more or less plumb liquor.

If a *blue* tint is required, add to the solution before putting in the goods, 2 or 3 drops either of sulphate, or of extract of indigo. (*See Nos.* 98 *and* 99).

261. Fine Lavender. Into a vessel of water as hot as the hand can bear, dissolve a little white soap—enough to raise a lather;

then add 1 gill archil liquor, and work the goods for 15 minutes, wring out and dry. To obtain a *redder* tint, boil 1 ounce cudbear, and use instead of the archil liquor. A *still redder* tint is attainable by leaving out the soap altogether.

262. Violet, Lilac, Wine Color, &c. Work the goods for 20 minutes in plumb liquor (*see No.* 111) in a copper pan or stoneware vessel; wash out repeatedly until the goods cease to taste of the liquor, then dry. To obtain a rich blue shade, add to the plumb liquor 1 fluid ounce either sulphate or extract of indigo. For a *red* shade, first dye a lavender by cudbear without soap. (*See No.* 261.)

263. French and Pearl White. Dissolve in hot water sufficient white soap to make a lather; then add ½ fluid ounce archil liquor; work the goods for 10 minutes, and wash out. A little cudbear may be used instead of archil, less or more, according to the shade required.

264. French and Pearl White. Put 1 fluid ounce plumb liquor (*see No.* 111) into a vessel of cold water; work the goods in it for 10 minutes; wash out and dry. For these shades the goods must be perfectly white (*see No.* 233) previous to dyeing.

265. Weld Yellow. Work the silk for an hour in a solution of alum, about 1 pound to the gallon; wring out and wash in warm water. Boil 2 pounds weld, strain the liquor, and work the silk in it for 30 minutes; lift, and add 1 pint of the alum in solution, to the weld liquor; work the silk 10 minutes longer, wring out and dry.

This gives a rich lemon yellow; deeper shades are made by using more weld: straw and amber tints are obtained by the use of a little annotto.

266. Bark Yellow. The process is the same as for dyeing *weld yellow*, using 2 pounds bark instead of the weld. The bark should be boiled in a bag.

267. Deep Rich Yellow. Proceed as in the receipt for *bark yellow;* except that, after lifting, instead of a pint of the alum solution, 2 fluid ounces single chloride of tin are added to the bark liquor; work 10 minutes, wash in water, and finish in a solution of white soap.

268. Gold and Straw. To warm water containing white soap, add 2 pints annotto liquor (*see No.* 95), work in this 15 minutes; wash out, then work for 20 minutes in a decoction of 8 ounces bark; lift, and add 1 fluid ounce red spirits (*see No.* 108); work 10 minutes more, wash out and finish. Different quantities of annotto and bark produce different shades.

269. Nankeen, Buff, &c. Make a solution of soap in warm water, add to it 1 pint annotto liquor (*see No.* 95); work in this for 20 minutes, wring out and finish; a deeper shade is obtained by using more annotto.

270. Salmon, Flesh, &c. Dye a nankeen according to the previous receipt, and add 2 ounces alum in solution to the cold water used for finishing.

271. Orange. Work the silk for 15 minutes in a strong warm solution of annotto (*see No.* 95); wash out in warm water and dry.

272. Yellow Drab. Into a vessel of warm water put 1 pint annotto liquor (*see No.* 95); work for 15 minutes and wash; then work for 15 minutes in a decoction of ½ pound sumach and 1 pound fustic; lift, and add 4 ounces copperas and 1 ounce alum in solution; work 10 minutes, wash in cold water and dry. A variety of drabs may be dyed in this way by varying the proportions of the sumach and fustic, and by introducing a little logwood or peachwood.

273. Drab. Work for 15 minutes in a decoction of 8 ounces sumach and 8 ounces fustic; lift, and add 4 ounces copperas; work for 20 minutes, and wash out in cold water; then work 15 minutes in a vessel of warm water containing ½ pint archil liquor, and dry.

274. Greenish Drab. For a greenish drab, add to the archil liquor a decoction of 4 ounces fustic and ½ fluid ounce chemic. (*See No.* 162).

For a purple tint, use 1 ounce alum in solution, instead of the chemic.

275. Slate or Stone Color. Work the silk for 30 minutes in a decoction of 1 pound sumach, 4 ounces fustic, and 4 ounces logwood; lift, and add a solution of 4 ounces copperas; work 30 minutes more, wash in cold water, and finish.

For different tints, vary the proportion of sumach, &c.

276. Common Green. Steep for an hour in a solution of 1 pound alum to the gallon of water; wash in warm water, then work for 30 minutes in a decoction of 6 pounds fustic; lift, and add 2 fluid ounces indigo extract (*see No.* 99); work for 30 minutes more, wash and finish. For blue-green use more indigo extract. Darker or lighter shades are dyed by using more or less in proportion of each ingredient.

277. Green. Work for 40 minutes in a decoction of 4 pounds fustic; lift, and add 1 pound alum in solution, and 2 fluid ounces indigo extract (*see No.* 99); work in this for 30 minutes, wash out in cold water containing ½ pint alum solution, and finish.

278. Pea Green. Steep for an hour in a solution of 8 ounces alum to the gallon of water, then wash out in warm water; boil 4 pounds ebony wood chips for an hour; take the clear liquor and work the silk in it for 30 minutes; lift, and add ½ fluid ounce indigo extract (*see No.* 99); work for 10 minutes; wash in cold water containing ½ pint alum solution, and dry.

The indigo extract must be added with caution, as too much will make the green too blue; it is safer to add less, and then, if necessary, lift, and add more.

279. Bottle Green. Work for an hour in a solution of 2 pounds alum and 1 pound copperas; wash out in warm water, then work for 30 minutes in a decoction of 6 pounds fustic; lift, and add 2 fluid ounces indigo extract (*see No.* 99); work for 20 minutes, wash out and finish.

280. Bottle Green. Proceed exactly as for *common green* (*see No.* 276) with the addition of 1 pound logwood to the 6 pounds fustic. The addition of a little more logwood makes a still deeper shade if required.

281. Olive. Work the silk for 30 minutes in a solution of 1 pound copperas and 4 ounces alum; wash out in hot water, then work for 30 minutes in a decoction of 2 pounds fustic and 4 ounces logwood; lift, and add 2 ounces alum in solution; work 10 minutes, wash and dry.

A little chemic (*see No.* 162) added to the last wash water will induce a greener hue if required.

282. Light Olive. Dye a light Prussian blue (*see No.* 256); then work for 20 minutes in a decoction of 2 pounds fustic and ½ pint archil liquor; lift, and add 1 ounce alum in solution; work 10 minutes and finish.

283. To Dye Mixed Fabrics Two Colors. Mixed fabrics of cotton and wool, such as coburgs, damasks, &c., may be dyed all of one color, or the cotton and wool in them each dyed a different color. This is seldom done except with new goods, or with very light colored goods which are desired to be dyed dark colors. As the process for dyeing woolens will seldom impart the same color to cottons, the two are dyed separately, and the method is quite simple. For most colors it is necessary to dye the woolen portion first, and then the cotton; but in a few cases the cotton must be the first to be acted on.

284. Green and Pink. First dye the woolen *green* by either of the methods given in Nos. 206, 207, &c. The cotton is then dyed pink, according to receipt No. 248.

285. Green and Crimson. Dye the woolen by working for an hour in 2 pounds tartar, 4 pounds alum, and 6 pounds fustic; lift, and add ½ pint indigo extract (*see No.* 99); wash out, and lay over night in 6 pounds sumach; then work for 30 minutes in red spirits (*see No.* 108) made to a strength of 1½° Baumé; wash out, and work for an hour in 5 pounds peachwood at blood heat; lift, and add a little alum; work in this, then wash out and finish.

286. Blue and Orange. First dye the cotton by the blue vat (*see No.* 130), wash out, and then dye the woolen by working an hour in a bath made up of 2 pounds tartar, 8 ounces cochineal, 2 pounds fustic, and 2 pints bichloride of tin; wash and dry.

In this way almost any two colors may be dyed upon woolen and cotton, although woven together, by proceeding according to the receipt for the color required on each sort of fibre. The wool is always dyed first, excepting in the case where the cotton is dyed in the blue vat, when the cotton has to be treated first. The same principle is applicable to silk and woolen fabrics, although in many cases the silk becomes more imbued than the cotton by the woolen dyes. A mixture of silk and cotton can be dyed in the same manner, but it is much more difficult, and cannot be done with all kinds of colors, and the process is seldom resorted to. But the intelligent dyer will be able to combine a variety of tints by following the rules and receipts given.

287. To Dye Mixed Fabrics one Color. If the mixed fabrics are required to be dyed one uniform color, the double process has often to be adopted, especially for cotton and woolen fabrics, thus:

288. Black on Cotton and Woolen Goods. First dye the woolen according to No. 192; then, after steeping the goods in sumach, dye the cotton by receipt No. 139.

289. Brown on Cotton and Woolen Goods by one Process. Work for 2 hours in catechu, as in No. 147; then work at a boiling heat for an hour with 8 ounces bichromate of potassa and 2 ounces tartar; next work for an hour in 2 pounds fustic and 8 ounces cudbear; wash and dry. For a deeper shade, or of a more chocolate hue, add 4 ounces logwood to the cudbear.

290. Black on Silk and Woolens by one Process. Work for an hour in a solution of 8 ounces tartar and 8 ounces copperas; wash out, then work for 15 minutes in a decoction of 4 pounds logwood; lift, and add 1 ounce chrome; work for 30 minutes and dry.

291. Black on Cotton, Silk and Wool, by one Process. Steep for 6 hours in 2 pounds sumach; then work for an hour in a solution of 6 ounces tartar, 6 ounces sulphate of copper, and 6 ounces copperas; wash out, and then work for half an hour in a decoction of 4 pounds logwood; lift, and add 1 ounce copperas; work for 10 minutes, wash and dry.

292. Deep Black. To obtain a very deep black, add 1 pound of bark to the logwood, and proceed as in last receipt.

293. Drabs on Cotton, Silk and Wool, by one Process. Work for half an hour in

8 ounces copperas and 4 ounces tartar; lift and drain; then work for half an hour in 4 ounces logwood and 1 ounce bichromate of potassa; wash out and dry. By varying the quantity of logwood, and by introducing a little fustic or peachwood in combination with the logwood, a great variety of drabs, slates or fawns can be produced.

These few receipts for mixed fabrics will show the care required in such operations, although, by practice, they become comparatively simple.

294. To Detect Animal or Vegetable Fibres. Treat the fabric with bichloride of tin heated to from 130° to 150° Fahr., when the cotton and linen become black, and the wool and silk remain unchanged.

295. To Detect Mixed Fabrics of Cotton and Wool. Dip a piece of the cloth in bleaching liquor; after a little while the woolen turns yellow, and the cotton white, and may easily be distinguished.

296. To Detect Cotton in Linen. The piece to be tested should be boiled to remove all dressing, and then dried; put a portion of the piece into common vitriol for about one minute; take it out and wash it in water several times, and then into a weak solution of soda or potash, and all the gummy matter formed is removed by gentle rubbing. By this process the cotton is dissolved and the linen remains, or any portion of the cotton that is not dissolved becomes opaque white, while the linen is transparent. By comparing the portion thus tested, with a similar portion not tried, the quantity of cotton present can easily be estimated.

297. To Detect Cotton in Linen. Take a small piece of the cloth, boil in water and dry; then take 3 parts, by weight, of sulphuric acid, and 2 parts of crushed nitrate of potassa; put the dry piece of cloth in this mixture for 6 or 7 minutes, and then wash it in water until there is no taste of acid; dry it at a gentle heat; next put it into a mixture of ether and alcohol, which will dissolve the cotton and not the linen. If the piece be weighed before and after putting it into the ether and alcohol, the quantity of cotton in the fabric can be accurately ascertained.

298. To Distinguish Cotton and Wool. Take a small piece of the cloth and boil in caustic soda; the wool will be dissolved, and the cotton remain. If the threads have been previously counted, their relative mixture can be found.

299. To Detect Cotton with Silk or Wool. Put a piece of the cloth into chlorine water or bleaching liquor. The cotton is whitened, and the silk and wool turn yellow, and can easily be distinguished by the aid of a pocket lens.

300. To Detect Cotton in Silk or Wool. Take a small piece and unravel the threads, and inflame them; the cotton burns away freely and leaves little or no black charcoal; the wool and silk shrivel up, leave a black charcoal, and give a strong smell.

Decidedly the best and safest method, and one applicable in all cases, is a microscopic examination, by which not only the structure, but also the nature of the fibre can be demonstrated. Cotton, wool and silk are easily distinguished by the microscope, as they differ materially in appearance. Cotton forms flat, narrow ribbons, curled up in spirals like those of a corkscrew; wool fibre is stouter than all others, and may be recognized by its scaly surface, while silk is the thinnest fibre, has the smoothest surface, and possesses the least structure. These appearances are very characteristic, and any one who has observed them once will ever afterwards recognize them again at first sight.

301. To Distinguish Silk and Wool in Fabrics. Silk can always be identified in a mixture with any other animal or vegetable fibre by means of concentrated hydrochloric acid, which dissolves it completely and immediately, without appreciably affecting any woolen or woody fibre with which the silk may have been interwoven. Strong sulphuric acid has also a powerful solvent effect upon silk, and is likewise much more destructive in its action upon cotton than the other acid. Should it be desired to determine the nature of any fibres remaining after the solution of the silk, it is first necessary to wash and collect them, when they will usually be found destitute of color. To decide whether wool is present or absent, a solution of picric acid may be employed, which instantly imparts a full yellow tint to the wool, but does not in the least affect cotton, linen, or China grass; so that it is only necessary to immerse the fabric in the dye, wring it out, and wash well with water. Should any portion remain of a yellow color, the presence of wool is indicated. Other methods can be employed similar in principle, but the picric acid is believed to be best. Discrimination between the different kinds of fibre can best be prosecuted by means of the microscope, but their quantity is best found by dissolving away one fibre, as already directed, and weighing.

Family Dyeing Receipts.

The following receipts and directions are excellent for dyeing on a small scale, and especially adapted for family use. The ingredients required can be obtained at any color store.

303. Black for Worsted or Woolen. Dissolve ¾ ounce bichromate of potash in 3 gallons water. Boil the goods in this 40 minutes; then wash in cold water. Then take 3 gallons water, add 9 ounces logwood, 3 ounces fustic, and one or two drops, D. O. V., or Double Oil of Vitriol; boil the goods 40 minutes, and wash out in cold water. This will dye from 1 to 2 pounds of cloth, or a lady's dress, if of a dark color, as brown, claret, &c.

All colored dresses with cotton warps should be previously steeped 1 hour in sumach liquor; and then soaked for 30 minutes in 3 gallons of clean water, with 1 cupful of nitrate of iron (*see No.* 116); then it must be well washed, and dyed as first stated.

304. Black for Silk. Dye the same as black for worsted; but previously steep the silk in the following liquor: scald 4 ounces logwood, and ½ ounce turmeric in 1 pint boiling water; then add 7 pints cold water. Steep 30 or 40 minutes; take out, and add 1 ounce sulphate of iron (copperas), dissolved in hot water; steep the silk 30 minutes longer.

305. Brown for Worsted or Wool. Water, 3 gallons; bichromate of potash, ¾ ounce. Boil the goods in this 40 minutes; wash out in cold water. Then take 3 gallons water, 6 ounces peachwood, and 2 ounces turmeric. Boil the goods in this 40 minutes; wash out.

306. Imperial Blue for Silk, Wool, and Worsted. Water, 1 gallon; sulphuric acid, a wine-glassful; imperial blue, 1 table-spoonful or more, according to the shade required. Put in the silk, worsted, or wool, and boil 10 minutes; wash in a weak solution of soap lather.

307. Sky Blue for Worsted and Woolen. Water, 1 gallon; sulphuric acid, a wine-glassful; glauber salts in crystals, 2 table-spoonfuls; liquid extract of indigo, 1 tea-spoonful. Boil the goods about 15 minutes; rinse in cold water.

308. Claret for Wool or Worsted. A Short Way of Dyeing the Same. Water, 3 gallons; cudbear, 12 ounces; logwood, 4 ounces; old fustic, 4 ounces; alum, ½ ounce. Boil the goods in it 1 hour. Wash. This will dye from 1 to 2 pounds of material.

309. Crimson for Worsted or Wool. Water, 3 gallons; paste cochineal, 1 ounce; cream of tartar, 1 ounce; nitrate of tin (*see No.* 113), a wine-glassful. Boil your goods in this 1 hour. Wash first in cold water, then in another vessel with 3 gallons warm water with a cupful of ammonia, the whole well mixed. Put in the goods and work well 15 minutes. For a bluer shade add more ammonia. Then wash out.

310. Fawn Drab for Silk. Hot water, 1 gallon; annotto liquor (*see No.* 95), 1 wine-glassful; 2 ounces each of sumach and fustic. Add copperas liquor according to the required shade. Wash out. It is best to use the copperas liquor in another vessel, diluted according to the shade desired.

311. Dark Drab for Silk may be obtained by using a little archil and extract of indigo.

312. Flesh Color for Dyeing Silk. Boiling water, 1 gallon; put in 1 ounce white soap, and 1 ounce pearlash. Mix well, then add a cupful of annotto liquor. (*See No.* 95.) Put the silk through several times, and proportion the liquor till you obtain the required shade.

313. Salmon Color for Silk may be obtained by first passing through the above liquor, and then through diluted muriate of tin. (*See No.* 113.)

314. Magenta for Silk, Wool or Worsted. Water, 1 gallon, heated up to 180 degrees; and magenta liquor, 1 tablespoonful; stir it well up. This will dye a broad ribbon 4 yards long, or a pair of small stockings. To dye a larger quantity of material, add more magenta liquor and water. The shade of color may be easily regulated by using more or less. Magenta Pink may be obtained by increased dilution.

315. Mauve for Silk, Wool or Worsted. Water, 1 gallon; add 1 table-spoonful sulphuric acid; then heat to boiling point. For a *very light mauve*, add 1 tea-spoonful imperial violet liquor; boil the same amount of material, as stated under Magenta, about 10 minutes. Rinse in cold water. If the color be too deep, use a little soap in rinsing, using warm water.

316. Violet Color for Worsted may be produced by using a table-spoonful of violet liquor instead of a tea-spoonful.

317. Pea Green for Silk. To 1 quart water, put ½ tea-spoonful picric acid, and rather more than ½ wine-glassful sulphuric acid, and a tea-spoonful paste extract of indigo; boil about 5 minutes, then add water to cool it down to blood heat, or 100° Fahr. Put in the silk, and work it about 20 minutes. The shade may be varied by adding more or less of the picric acid, or extract of indigo; if more of either be added, boil separately in a little water, and add to the previous liquor.

318. Pea Green for Worsted. Use the same materials as the aforesaid; but boil all the time in 1 gallon of water for about 20 or 30 minutes.

319. Dark Green for Worsted. This may be obtained by using a larger quantity of material, in the same way as the last.

320. Plum Color for Worsted, Silk or Cotton. Water, 1 gallon; sulphuric acid, 1 tea-spoonful; glauber salts, in crystals, 2 table-spoonfuls; violet liquor, 1 table-spoonful; magenta liquor, ½ table-spoonful. Boil the article (silk, wool or worsted), about 10 minutes.

321. Remarks on Dyeing Cotton. Cotton should be dyed the above colors separately, and by first running them through weak gall liquor, and weak double muriate of tin. Then wash well, and work in the aforesaid liquor, according to color and shade. The dyeing liquor should be cold.

322. Scarlet on Worsted or Wool. 3 gallons water, 2 ounces dry cochineal, 1 ounce cream of tartar, 1 wine-glassful nitrate of tin; boil the goods 1 hour. To give the goods a yellower hue, add a little young fustic to the above mixture. Wash out as before.

323. Yellow for Dyeing Silk. Proceed the same as in dyeing pea green, omitting the extract of indigo, and using oxalic tin instead of sulphuric acid.

324. To Dye Feathers. First steep them a few hours in warm water.

325. Blue may be dyed by extract of indigo and boiling water. Simmer over the fire a few minutes.

326. Green. Verdigris and verditer, 1 ounce each; and gum water. Dip the feathers. Or mix the indigo liquor with Persian berry liquor.

327. Lilac. Use cudbear and hot water.

328. Red. Brazil wood, a little vermilion and alum, and vinegar. Boil 30 minutes, and then dip the feathers.

329. Yellow, by turmeric.

330. Scarlet, by cochineal, cream of tartar, and muriate of tin. (*See No.* 113.)

331. To Dye Dove or Slate Color. Boil a teacup of black tea in an iron pot, adding a tea-spoonful of copperas. The depth of color will depend on the quantity of water used. Dye the articles in this and then hang them up to drain, finally rinsing out in soapsuds.

332. Aniline Red. This produces a color varying from the deepest crimson to a very brilliant and beautiful rose pink, according to the strength of the dye. All that is necessary is to enclose the aniline in a small muslin bag, and having a kettle (tin or brass) filled with moderately hot water, rub the substance out. Then immerse the articles to be colored, and in a short time they are done. The dye is so readily absorbed that care is required to prevent spotting. No mordant is required, although it improves the color to wring the goods out of strong soapsuds before putting them in the dye. This is a permanent color for woolen or silk.

333. Aniline Blue. To 100 pounds of fabric dissolve 1½ pounds aniline blue in 3 quarts hot alcohol; strain through a filter and add it to a bath of 130° Fah.; also 10 pounds glauber salts, and 5 pounds acetic acid. Enter the goods and handle them well for 20 minutes; next heat it slowly to 200° Fah.; then add 5 pounds sulphuric acid diluted with water. Let the whole boil 20 minutes longer, then rinse and dry. If the aniline be added in two or three proportions during the process of coloring, it will facilitate the evenness of the color. Hard and close wove fabrics, such as braid, ought to be prepared in a boiling solution of 10 pounds sulphuric acid and 2 pounds tartaric acid before coloring with the aniline, as this will make the fabric more susceptible to the color.

334. To Dye Hats. A bath for dyeing 12 dozen hats consists of 144 pounds logwood, 12 pounds green sulphate of iron or copperas, 7½ pounds verdigris. The copper is made of a semi-cylindrical shape, and should be surrounded with an iron jacket, or case, into which steam may be admitted, so as to raise the temperature of the interior bath to 190° Fah., but no higher; otherwise the heat is apt to affect the stiffening varnish, called the gum, with which the body of the hat has been imbued. The logwood having been introduced and digested for some time, the copperas and verdigris are added in successive quantities, and in the above proportions, along with every successive two or three dozen of hats suspended upon the dipping machine. Each set of hats, after being exposed to the bath, with occasional airings, during 40 minutes, is taken off the pegs, and laid out upon the ground to be more completely blackened by the peroxydizement of the iron with the atmospheric oxygen. In 3 or 4 hours the dyeing is completed. When fully dyed, the hats are well washed in running water.

335. Spirit Stiffening for Hats. 7 pounds orange shellac; 2 pounds gum sandarac; 4 ounces gum mastic; ½ pound amber resin; 1 pint solution of copal; 1 gallon spirit of wine, or wood naphtha.

The shellac, sandarac, mastic, and resin are dissolved in the spirit, and the solution of copal is added last.

336. Alkali Stiffening for Hats. 7 pounds common block shellac; 1 pound amber resin; 4 ounces gum thus; 4 ounces gum mastic; 6 ounces borax; ½ pint solution of copal.

The borax is first dissolved in about 1 gallon warm water. This alkaline liquor is put into a copper pan (heated by steam), together with the shellac, resin, thus, and mastic, and allowed to boil for some time, more warm water being added occasionally until it is of a proper consistence; this may be known by pouring a little on a cold slab, somewhat inclined, and if the liquor runs off at the lower end, it is sufficiently fluid. If, on the contrary, it sets before it reaches the bottom, it requires more water. When the whole of the gums seem dissolved, ½ pint of wood naphtha must be introduced, with the solution of copal; then the liquor must be passed through a fine sieve, and it will be perfectly clear and ready for use. This stiffening is used hot. The hat bodies, before they are stiffened, should be steeped in a weak solution of soda in water, to destroy any acid that may have been left in them (as sulphuric acid is used in the making of the bodies.) If this is not attended to, should the hat body contain any acid when it is dipped into the stiffening, the alkali is neutralized, and the gums consequently precipitated. After the body has been steeped in the alkaline solution, it must be perfectly dried in the stove before the stiffening is applied; when stiffened and stoved, it must be steeped all night in water to which a small quantity of the sulphuric acid has been added; this *sets* the stiffening in the hat body, and finishes the process.

To Remove Stains, Spots,

&c. The following receipts embrace directions for cleaning, and removing stains of every kind, from clothing, linen, etc., and articles pertaining to the household. Receipts for cleansing other articles will be found elsewhere under their appropriate headings.

338. To Remove Resin Spots from Silk. Stains by wax, resin, turpentine, pitch, and substances of a resinous nature, may be removed by pure *alcohol*. It frequently happens that when common turpentine is employed to remove grease, varnish or paint stains from silk, the turpentine itself leaves a stain almost as objectionable as the original one, which it was used to remove. These stains are due to the resin which is held in solution by the turpentine, and which remains in the silk after the volatile or spirituous portion has evaporated. Alcohol applied to the stains with a clean sponge will remove the spots, because alcohol dissolves the resin. The silk stains should be moistened with the alcohol first, and allowed to remain soaked for a few minutes. Fresh alcohol is then applied with the sponge, and with a slight rubbing motion. It is then wiped as dry as possible and afterward permitted to dry perfectly in the open air.

339. To Remove Pitch, Varnish, or Oil-paint Stains. When pitch, varnish, or oil-paint stains have become dry, they should be softened with a little butter or lard, before using turpentine and soap. In these cases, a simple way is to soak the part in spirits of turpentine, and, when softened, to wash it off with the same fluid. *Burning-fluid* combines the solvent powers of both alcohol and turpentine. Benzine is also good. Chloroform will also remove paint from a garment when almost everything else fails. The fats, resins, and unctuous oils, are dissolved by *essential* oils, as *oil of turpentine*. Common spirits of turpentine, however, requires to be purified by re-distillation, or it will leave a resinous stain upon the spot where it is used. (*See last receipt.*)

340. To Remove Paint Stains from Clothes. Chloroform is an excellent medium for the removal of stains of paint from clothes, etc. It is found that portions of dry white paint, which resisted the action of ether, benzole, and bisulphide of carbon, are at once dissolved by chloroform. If the paint is fresh, turpentine or alcohol will remove it. (*See No.* 338.)

341. To Remove Wax Stains from Silk. Mix powdered French chalk with lavender water to the thickness of mustard. Put it on the stain, and rub it gently with the finger or palm of the hand. Put a sheet of clean blotting paper and brown paper over it, and smooth it with a warm iron. When dry the chalk must be removed, and the silk gently dusted with a white handkerchief. If a faint mark still remains, a second application of French chalk and lavender water will generally remove it. If the wax stain has fallen thickly on the silk, it should be removed first carefully with a penknife.

342. To Remove Wax Spots from Cloth. Remove, by scraping with a knife, as much of the wax as you can without injury to the fabric; drop benzine on the spot, then with a sponge rub it gently; repeat it till the spot disappears.

343. To Remove Spermaceti, or Stearine Stains. To remove spots of spermaceti, scrape off as much as you can with a knife, then lay a thin, soft, white blotting paper upon the spots, and press it with a warm iron. By repeating this you will draw out the spermaceti. Afterwards rub the cloth where the spots have been, with some very soft brownish paper.

344. To Remove Grease Spots. To do this without injury to the color of the fabric, is sometimes easy, frequently most difficult, and often impossible. Much may depend upon skillful and persevering manipulation; and although various agents are oftentimes valuable, yet good soap, after all, is the chief reliance. Grease spots may generally be removed by the patient application of soap and soft water, but other means are also employed. Ox-gall is an excellent and delicate cleansing agent. It is a liquid soda soap. It removes grease, and is said to fix and brighten colors, though it has a greenish tinge, which is bad for the purity of white articles. Aqua ammonia is also good for removing grease spots from any fabric. Use the ammonia nearly pure, and then lay white blotting paper over the spot and iron it lightly. (*See also No.* 126.)

345. To Remove Grease and Dirt from Cloth and Woolen Articles. Place a cotton or woolen cloth, or a piece of blotting paper, under the article to be cleansed, then rub upon the spots some pure benzine, and the grease or dirt will disappear as if by magic.

Be sure to place a cloth under the garment to be operated upon, otherwise a circular stain will remain, which cannot be removed. The benzine drives the grease through the article to be cleaned, and is absorbed by the cloth placed under it. After the spot is removed, continue to rub with a dry cloth until the benzine is evaporated; this also is done to avoid a stain.

346. Cautions about Benzine. From the facility with which it removes grease spots from fabrics, this substance has come to be regarded almost as a household indispensable. But few persons, however, realize the explosive character of benzine or the dangers attending the careless handling of the liquid. Being one of the most volatile and inflammable products resulting from the distillation of petroleum, it vaporizes with great rapidity, so that the contents of a 4 ounce vial, if overturned, would render the air of a moderate sized room highly explosive. The greatest care should be exercised in handling this substance, in proximity to fire, and it is important to remember that the vapor escaping from an uncorked bottle will cause a flame to leap over a space of several feet.

347. To Remove Grease from Cloth. Take 1 quart lime; add thereto as much water as will dissolve the lime and leave about 1 quart clear water after it has been well stirred and settled. Let it stand about two hours, and then pour off the clear liquid into another vessel. Now add to it ½ an ounce of pearlash; stir it well, and, when settled, bottle it for use. This liquor is to be diluted with water, to suit the strength or delicacy of the color of the cloth. It is applied with a piece of coarse sponge, rubbing out the grease, and applying clear water afterwards.

This is one of the best receipts known for the extraction of grease; but it is destructive to certain vegetable colors.

348. To Remove Grease Spots from Cloth. Soft soap, and fuller's earth, of each ¼ pound; beat well together in a mortar, and form into cakes. The spot, first moistened with water, is rubbed with a cake, and allowed to dry, when it is well rubbed with a little warm water, and rinsed or rubbed off clean.

349. Scouring Balls. Dry fuller's earth, moistened with the juice of lemons; add a small quantity of pearl ashes, and a little soft soap; knead the whole well together into a thick elastic paste; form it into small balls and dry them in the sun. When used, moisten the spot on the clothes with water; then rub it with the ball, and let the spot dry in the sun. When washed with pure water the spot will disappear.

350. To Remove Grease from Cloth or Silk. Separate the yolk of an egg from the white as perfectly as possible. Then stretch the fabric on a board, and with a soft clothes brush dip into the yolk, and rub the spot with it until the grease seems loosened. The yolk will not injure the most delicate colors, but the rubbing may, if too severe. Then rinse with warm rain water, rubbing the edges with a damp cloth, and clapping the whole between dry towels. If the stain is not quite gone, repeat the process. It will not do so well for fabrics mixed with cotton or linen.

351. To Remove Grease from Silk or Velvet. Rub the spots on the silk *lightly* and *rapidly* with a clean soft cotton rag dipped in chloroform, and the grease will immediately disappear without injuring the color of the silk. Repeat the operation if necessary. Be careful to rub the article rapidly and lightly, then finish with a clean dry cloth. If these precautions are not taken, a slight stain is apt to be the result. Very highly *rectified* benzine, such as is prepared by the first-class druggists, will also immediately remove grease from the most delicate colored silks.

352. To Remove Grease from Silk. Take French chalk finely scraped, and put it on the grease spot, holding it near the fire, or over a warm iron reversed, or on a waterplate in which is boiling water. This will cause the grease to melt, and the French chalk will absorb it, and it may then be brushed or rubbed off; or, put a little powdered French chalk on the spot, cover it with a piece of white blotting-paper, and over that a piece of brown wrapping paper, and apply a hot flat-iron. If any grease remains, proceed as before, until it is all extracted. The French chalk is a fine soluble powder of a dry absorbent quality, acting upon silks the same as fuller's earth does upon cloth.

The above plans may be adopted when you desire to extract the grease immediately; but if time is not an object, proceed as follows:

Sprinkle pulverized French chalk upon the spot and put the article in a dark place, and in a few days the grease will entirely disappear. We think this last method the best, as the heat from the iron will sometimes injure silk of a delicate tint.

353. To Remove Grease Spots from Silk. Grease spots may be taken from silks in the following manner: Upon a wooden table lay a piece of woolen cloth or baize, upon which lay smoothly the part stained, with the right side downwards. Having spread a piece of brown paper on the top, apply a flat-iron just hot enough to scorch the paper. About five or eight seconds is usually sufficient. Repeat until the spot is extracted. Then rub briskly with a piece of writing paper. *(See last receipt.)*

354. French Scouring Drops for Removing Grease. Camphene, 8 ounces; pure alcohol, 1 ounce sulphuric ether, 1 ounce; essence of lemon, 1 drachm; or, spirits of wine, 1 pint; white soap, 3 ounces; ox gall, 3 ounces; essence of lemon, ½ ounce.

355. To Remove Grease from Velvet. Grease may be taken out of velvet by a little turpentine, poured over the spot; then rub briskly with a piece of clean dry flannel. Repeat the application, if necessary, and hang the article in the air, to remove the smell. (*See No.* 351.)

356. Simple Method of Removing Grease Spots from Silk. Take a visiting or other card; separate it, and rub the spot with the soft internal part, and it will disappear without taking the gloss off the silk. This is a simple and valuable receipt. Be careful and rub the silk on the *wrong side*, as the card sometimes will soil delicate colored silks, but if the above precaution is taken, the spot cannot be seen on the right side of the silk.

357. To Remove Oil from Carpets. To take oil out of a carpet, as soon as it is spilled put on plenty of wheat flour or whiting, to absorb the oil and keep it from spreading. If the oil is near a seam, rip it, so that the spot will not spread, and put whiting on the floor under the carpet. Next day sweep up all the flour above and under the carpet with a stiff brush, and put on plenty of fresh flour. To take out grease spots, rub them with white flannel dipped in raw spirits of turpentine. If they show after a while, rub again on both sides. If there are grease spots on the floor, remove them with potter's clay before the carpet is laid down.

358. To take Grease Spots out of Carpets. Mix a little soap into a gallon of warm soft water, then add ½ ounce of borax; wash the part well with a clean cloth, and the grease or dirty spot will soon disappear.

359. To Remove Oil Stains from Leather and Paper. Oil stains may be removed from leather, paper, &c., by applying pipe-clay, powdered and mixed with water to the thickness of cream; leave it on for four hours. This will not injure the best colors.

360. Methods of Removing Various Stains. Fruit-stains, wine-stains, and those made by colored vegetable juices, are often nearly indelible, and require various treatment. Thorough rubbing with soap and soft water; repeated dipping in sour butter-milk, and drying in the sun; rubbing on a thick mixture of starch and cold water, and exposing long to sun and air, are among the expedients resorted to. Sulphurous acid is often employed to bleach out colors. It may be generated at the moment of using, by burning a small piece of sulphur in the air, under the wide end of a small paper funnel, whose upper orifice is applied near the cloth. Coffee and chocolate stains require careful soaping and washing with water at 120°, followed by sulphuration. If discoloration has been produced by acids, water of ammonia should be applied; if spots have been made by alkaline substances, moderately strong vinegar may be applied; if upon a delicate article, the vinegar should be decolorised by filtering through powdered charcoal.

361. The Effects of Acids and Alkalies upon Different Colors. The effect of acids upon blacks, purples, blues (except those produced by indigo or Prussian blue), and upon all those shades of colors which are produced by means of iron, archil, and astringent substances, is to turn them red. They render yellows more pale, except those produced by annotto, which they turn to an orange color.

Alkalies turn scarlets, and all reds produced by Brazil or logwood, to a violet color; they turn green (upon woolen cloths) to yellow, and they give a reddish cast to the yellow produced by annotto. The effect of the perspiration is the same as that of the alkalies.

Spots occasioned by acids are removed by alkalies, and *vice versâ*. *(See last receipt.)*

362. To Restore Colors that have been Injured by the use of Re-Agents. The colors of cloths are often injured by the re-agents made use of in order to restore them effectively; when such is the case we must not only understand the general principles of the art of dyeing, but the nature and composition of the particular dye that was originally employed for dyeing the cloth whose color is to be restored, and thus enabled to modify the means accordingly. Thus, when, after using an alkali to remove an acid spot upon brown, violet, or blue cloth, &c., there remains a yellow spot, the original color is again produced by means of a solution of tin. A solution of the sulphate of iron restores the color to those brown cloths which have been dyed with galls. Acids give to yellow cloths which have been rendered dull or brown by alkalies, their original brightness. When black cloths dyed with logwood have any reddish spots occasioned by acids, alkalies turn such spots to a yellow color, and a little of the astringent principle makes them black again. A solution of 1 part of indigo in 4 parts of sulphuric acid, properly diluted with water, may be successfully employed to restore a faded blue color upon wool or cotton. Red or scarlet colors may be restored by means of cochineal, and a solution of muriate of tin, &c. (*See No.* 113.)

363. The Choice of Re-Agents for Restoring Color. The choice of re-agents is not a matter of indifference; vegetable acid (*Decolorized Vinegar, see Index*), is generally preferable to mineral acids. The sulphurous acid (*see No.* 360), however, may be used for spots from fruit; it does not injure blue upon silk, or the colors produced by astringents; nor does it affect yellow upon cotton. A volatile alkali (*Water of Ammonia*) succeeds better than a fixed alkali in removing spots produced by acids. They are usually made use of in the form of vapor, and act quickly, seldom injuring the color of the cloth.

364. To Remove Fruit Stains. Spots caused by fruit are removed by sulphurous acid, or what is still better, by water acidulated with a little muriatic or oxalic acid, or salt of lemons; but care must be taken not to apply this liquid to colors that it will injure. A lighted sulphur match held under the stain will produce sufficient sulphurous acid.

365. To Remove Fruit and other Stains from Linen. Fruit and other spots on linen may be removed by applying to the part, previously washed clean, a weak solution of chlorine, chloride of lime, spirits of salts (muriatic acid), oxalic acid, or salts of lemon, in warm water, and frequently by merely using a little lemon juice. The part should be again thoroughly rinsed in clear warm water (without soap), and dried.

Many other stains may be taken out by dipping the linen in sour butter-milk, and drying it in a hot sun. Then wash it in cold water, and dry it, 2 or 3 times a day.

366. To Remove Acid Stains from Linen, &c. These may be removed by the following methods: Wet the part and lay on it some salt of wormwood (*carbonate of potassa*); then rub it, without diluting it with more water.

Or: Tie up in the stained part some pearl-ash; then scrape some soap into cold soft water to make a lather, and boil the linen till the stain disappears.

367. To Remove Acid Stains from Garments. Chloroform will restore the color of garments, where the same has been destroyed by acids.

When acid has accidentally or otherwise destroyed or changed the color of the fabric, ammonia should be applied to neutralize the acid. A subsequent application of chloroform restores the original color.

Spots produced by hydrochloric or sulphuric acid can be removed by the application of concentrated ammonia, while spots from nitric acid can scarcely be obliterated.

368. To Remove Alkali Stains from Garments. Spots produced by alkalies, such as soap-boiler's lye, soda, ammonia, etc., can generally be made to disappear completely by the prompt application of dilute acetic acid and a good deal of water. (*See No.* 360.)

369. To Remove Claret or Port Wine Stains. Apply a little table salt to the spot stained, and also moisten it with sherry. After washing, no trace of the stain will be left. The acid contained in claret decomposes the salt, and sets free chlorine (bleaching gas), which removes the vegetable coloring matter of the wine. If the stain is from port, sherry should be added, as it also contains acid.

370. To Remove Stains of Wine, Fruit, &c., after they have been long in the Linen. Rub the part on each side with yellow soap; then lay on a mixture of starch in cold water very thick; rub it well in, and expose the linen to the sun and air till the stain comes out. If not removed in 3 or 4 days, rub that off and renew the process. When dry it may be sprinkled with a little water.

371. To Remove Stains of Iodine. Stains of iodine are removed by *rectified* spirit.

372. To take out all Stains which are not Metallic. Mix 2 tea-spoonfuls of water with one of spirit of salt (muriatic acid); let the stain lie in it for one or two minutes; then rinse the article in cold water. This will be found particularly useful in removing stains from white napkins.

373. Prepared Ox-gall for taking out Spots. Boil together 1 pint of ox-gall and 2 ounces powdered alum; to which add 2 ounces common salt; let the liquor settle; add a few drops essence of lemon, pour it off into a bottle, and cork tightly.

374. Scouring Balls for General Purposes. In order to remove a stain, the cause or origin of which is doubtful, a composition is requisite which possesses various powers. The following is a good one for such purposes: Dissolve some white soap in alcohol, and mix with it the yolks of 4 or 5 eggs; add gradually a little spirits of turpentine, and sufficient fuller's earth to make the mixture into balls. To remove a stain, wet the spot with soft water, rub it with a ball of the above composition, then rub the cloth and wash out. This will remove almost any stain, except ink and other solutions of iron.

375. To Remove Iron Mould or Ink Stains. For iron mould or ink stains, lemon juice or salt of sorrel (oxalate of potash) may be used. If the stains are of long standing, it may be necessary to use oxalic acid, which is much more powerful. It may be applied in powder upon the spot, previously moistened with water well rubbed on, and then washed off with pure water. It should be effectually washed out, for it is highly corrosive to textile fibres. (*See also No.* 127.)

376. To Remove Iron Mould. The part stained should be remoistened with ink, and this removed by the use of muriatic acid diluted with 5 or 6 times its weight of water, when it will be found that the old and new stain will be removed simultaneously. This is a very effectual method.

377. To Remove Stains of Iron Mould from Fabrics. The removal of these stains is a matter of some difficulty if they have remained on a fabric for some time. The usual substances employed for this purpose (oxalic acid or quadroxalate of potassa) require placing, in concentrated solution, in contact with the material for a considerable time, thereby materially weakening and rotting the fibre. The following method is free from this objection, and will remove stains of long standing almost immediately: Wet the mark with yellow sulphide of ammonium, by which it will be immediately blackened, and allow it a minute or so to penetrate; then wash out the excess of sulphide, and treat the black spot with cold dilute muriatic acid, by which it is immediately removed. Finally, wash well with water.

378. To Make Essential Salt of Lemons, for removing iron moulds, ink spots, and stains from linen and cotton. Take 1 ounce of oxalic acid in fine powder, mix with 4 ounces of cream tartar, and put it up in small oval boxes.

379. To Remove Ink, Iron Mould, &c., from Linen. Wet the finger in water, dip it in the powder (*see last receipt*), and rub it on the spot gently, keeping it rather moist, and the stain will disappear without injuring the fabric. After the stain disappears, wash the linen in pure water. The salt of lemon used as a beverage is simply tartaric acid, put up in long bottles. The above is poisonous if swallowed.

380. To Remove Iron Mould and Ink from Delicate Linen Fabrics. These may be taken out by wetting the spots in milk, then covering them with common salt. It should be done before the garments have been washed. Another way to take out ink is to dip it in melted tallow. For fine, delicate articles, this is the best way.

381. To take out Mildew Spots. Wet the spots with a solution of chloride of soda (Labarraque's solution), or of chloride of lime (bleaching fluid), or with chlorine water, and they will disappear immediately. Fruit and wine stains of all kinds may be removed in this way. (*See also No.* 128.) Starched linen which has contracted mildew spots will require an application each day for 2 or 3 days; rinsing out and bleaching in the sunshine after each application.

382. To Remove Mildew. Mildew is easily removed by rubbing or scraping a little common yellow soap on the article, and then a little salt and starch on that. Rub all well on the article, and put in the sunshine. Or, soap the linen previously wetted, and apply salt and lemon juice to both sides; or apply finely powdered pipe clay, or fuller's earth, or finely powdered chalk. Expose it for several hours to the atmosphere.

383. To Extract Mildew. Mix soft soap with powdered starch, half as much salt, and the juice of a lemon, and lay on with a brush. Let it lay on the grass day and night till the stain is gone. This is a good receipt. Or, take 2 ounces chloride of lime, pour on it a quart of boiling water, then add 3 quarts of cold water; steep the linen 10 or 12 hours, when every spot will be extracted.

Mix oxalic acid, citric acid, and milk, together; rub into the linen; repeat as it dries; wash, and bleach on the grass.

384. To Remove Common Ink Stains. Ink stains may be readily removed from white articles by means of a little salt of lemons, diluted muriatic acid, oxalic acid, or tartaric acid, and hot water; or by means of a little solution of chlorine or chloride of lime. When the stain is caused by ink manufactured with logwood, a red mark remains, which may be removed by the application of a little chloride of lime. All strong acids and alkalies tend to injure the fabric; therefore, immediately the stains are removed, the spots should be well rinsed, and repeatedly, in cold water.

385. To Remove Stains made by Hair Dye, or Indelible Ink. The staining principle of common indelible ink is nitrate of silver. It may be removed by first soaking in a solution of common salt, which produces chloride of silver, and afterwards washing with ammonia, which dissolves the chloride. Nitrate of silver, or hair dye stains can be removed by a solution of 10 grains of cyanide of potassium, and 5 grains of iodine to 1 ounce of water; or a solution of 8 parts of perchloride of mercury and muriate of ammonia in 125 parts of water. (*See Nos.* 129 *and* 387.)

386. To Remove Marking-Ink from Linen. Dip the garment in a solution of 1 ounce cyanide of potassium in 4 ounces of water. After a few hours the stain will be obliterated. This is very effectual, but the mixture is highly poisonous, and should be carefully removed.

387. To Remove Silver Stains from the Hands. Put ¼ pound glauber salts, ¼ pound of the chloride of lime, and 8 ounces of water, into a little wide-mouthed bottle, and when required for use pour some of the thick sediment into a saucer, and rub it well over the hands with pumice stone or a nail-brush, and it will clean the fingers quite equal to cyanide, but without any danger. This will do to use over again until exhausted, and should be kept corked up. The disagreeable smell may be entirely avoided by the liberal use of lemon juice, which not only entirely removes the smell, but whitens the hands.

388. To Remove Stains from the Hands. Ink stains, dye stains, fruit stains, etc., can be immediately removed by dipping the fingers in warm water and then rubbing on the stain a small portion of oxalic acid powder and cream of tartar, mixed together in equal quantities, and kept in a box. When the stain disappears, wash the hands with fine soap. This mixture, being poisonous, must be kept out of the reach of children. A few drops of oil of vitriol (sulphuric acid) will also remove most stains from the hands without injuring them. Care must, however, be taken not to drop it upon the clothes. It will remove the color from woolen, and eat holes in cotton fabrics. The juice of ripe tomatoes will remove the stain of walnuts from the hands, without injury to the skin.

389. To take Ink Stains out of Mahogany. Put a few drops of spirits of nitre (nitric acid) in a tea-spoonful of water, touch the spot with a feather dipped in the mixture, and on the ink disappearing, rub it over immediately with a rag wetted in cold water, or there will be a white mark, which will not be easily effaced.

390. To take Ink Spots out of Mahogany. Apply spirits of salts (muriatic acid) with a rag until the spots disappear, and immediately afterward wash with clear water.

391. To Remove Ink from Mahogany. To ½ pint of soft water put 1 ounce of oxalic acid, and ½ ounce of butter (terchloride) of antimony; shake it well, and when dissolved it will be very useful in extracting stains from mahogany, as well as ink, if not of too long standing.

392. To Extract Ink from Floors. Remove ink from floors by scouring them with sand wet with water and the oil of vitriol, mixed. Then rinse them with strong saleratus water.

393. To Remove Stains on Mahogany Furniture. Stains and spots may be taken out of mahogany furniture by the use of a little aquafortis, or oxalic acid and water, by rubbing the part with the liquid, by means of a cork, till the color is restored; observing afterwards to well wash the wood with water and to dry and polish as usual.

394. To Extract Oil from Boards, Marble or other Stones. Make a strong lye of pearlashes and soft water, and add as much unslacked lime as it will take up; stir it together, and then let it settle a few minutes; bottle it and stop close; have ready some water to dilute it when used, and scour the part with it. If the liquor should lie long on the boards, it will draw the color out of them; therefore do it with care and expedition. When used for marble, the surface may be improved by rubbing or polishing afterward with fine putty-powder and olive oil. (*For Putty Powder, see Index.*)

395. To take Oil and Grease out of Boards. Make a paste with fuller's earth and hot water, cover the spots therewith, let it dry on, and the next day scour it off with soft or yellow soap.

396. To Clean Marble. To clean marble, mix quicklime with strong lye, so as to form a mixture having the consistency of cream, and apply it immediately with a brush. If this composition be allowed to remain for a day or two, and be then washed off with soap and water, the marble will appear as though it were new.

397. To Clean Marble. Take 2 parts of common soda, 1 part of pumice-stone, and 1 part of finely powdered chalk; sift it through a fine sieve, and mix it with water; then rub it well all over the marble, and the stains will be removed; then wash the marble over with soap and water, and it will be as clean as it was at first.

398. How to Clean Marble. The following is an excellent way of cleaning marble:

First, brush the dust off the piece to be cleaned, then apply with a brush a good coat of gum arabic, about the consistency of thick office mucilage; expose it to the sun or dry wind, or both. In a short time it will crack and peel off. If all the gum should not peel off, wash it with clean water and a clean cloth. If the first application does not have the desired effect, it should be applied again.

399. To Clean Marble. Mix ½ pound soft soap with the same of pounded whiting, 1 ounce soda, and a piece of stone-blue the size of a walnut; boil these together for ½ of an hour; whilst hot, rub it over the marble with a piece of flannel, and leave it on for 24 hours; then wash it off with clean water, and polish the marble with a piece of coarse flannel, or, what is better, a piece of an old hat.

400. To take Stains out of White Marble. Take 1 ox-gall, 1 wine-glass soap lees, ¼ wine-glassful turpentine; mix and make into a paste with pipe clay. Put on the paste over the stain and let it remain for several days. If the stain is not fully removed a second application will generally prove sufficient.

401. To Remove Oil Stains in Marble. Stains in marble caused by oil can be removed by applying common clay saturated with benzine. If the grease has remained long enough it will have become acidulated, and may injure the polish, but the stain will be removed.

402. To Remove Iron Mould or Ink from Marble. Iron mould and ink spots may be taken out in the following manner: Take ½ ounce butter of antimony and 1 ounce oxalic acid, and dissolve them in 1 pint rain water; add flour, and bring the composition to a proper consistence. Then lay it evenly on the stained part with a brush, and after it has remained for a few days wash it off, and repeat the process if the stain is not quite removed.

403. To Remove Stains from Marble. Mix an ox-gall with a quarter of a pound of soap-boiler's lye, and an eighth of a pound of oil of turpentine, and add enough pipe-clay earth to form a paste, which is then to be placed upon the marble for a time, and afterwards scraped off; the application to be repeated until the marble is perfectly clean. It is quite possible that a faint trace of the stains may be left; but this will be almost inappreciable. Should the spots be produced by oil, these are to be first treated with petroleum, for the purpose of softening the hardened oil, and the above-mentioned application may be made subsequently.

404. To Remove Printing Ink from any Article. Printing ink can be readily taken from any article by means of ether or oil of turpentine. Pure benzine will also have a similar effect.

405. To Remove the Varnish from Oil Paintings, &c. Varnish and dirt can be removed by washing over with a weak solution of carbonate of ammonia, wiping it off with a sponge wetted with water as soon as it has fulfilled its object; if allowed to remain too long it will injure the oil colors. Another way is to spread a thick coat of wet fuller's earth over the surface of the varnish, leaving it on long enough to soften it; it may then be removed by washing.

406. To Clean Pictures. Having taken the picture out of the frame, take a clean towel, and, making it quite wet, lay it on the face of the picture, sprinkling it from time to time with clean soft water; let it remain wet for 2 or 3 days; take the cloth off and renew it with a fresh one. After wiping the picture with a clean wet sponge, repeat the process till you find all the dirt is soaked out of it; then wash with a soft sponge, and let it get quite dry; rub it with some clear nut or linseed oil, and it will look as well as when freshly done.

407. To Clean Oil Paintings. Put into 2 quarts of strong lye, ¼ pound of Genoa soap, rasped very fine, with 1 pint spirits of wine; let them simmer on the fire for half an hour, then strain them through a cloth. Apply the preparation with a brush to the picture, wipe it off with a sponge, and apply it a second time, which will remove all dirt. Then with a little nut-oil warmed, rub the picture and let it dry. This will make it look as bright as when it came out of the artist's hands. If the canvas is injured by damp, mildew or foul air, the first thing to be done is to stretch and line it with new canvas.

408. To Clean Japanned Waiters and Urns. Rub on with a sponge a little white soap and some lukewarm water, and wash the waiter or urn quite clean. Never use hot water, as it will cause the japan to scale off. Having wiped it dry, sprinkle a little flour over it; let it rest a while, and then rub it with a soft dry cloth, and finish with a silk handkerchief. If there are white heat marks on the waiters, they will be difficult to remove; but you may try rubbing them with a flannel dipped in sweet oil, and afterwards in spirits of wine. Waiters and other articles of *papier maché* should be washed with a sponge and cold water, without soap, dredged with flour while damp, and after a while wiped off, and then polished with a silk handkerchief.

409. Method of Cleaning Paper Hangings. Cut into 8 portions a loaf of bread 2 days old; it must neither be newer nor staler. With one of these pieces, after having blown off all the dust from the paper to be cleaned, by the means of a good pair of bellows, begin at the top of the room, holding the crust in the hand, and wiping lightly downward with the crumb, about half a yard at each stroke, till the upper part of the paper is completely cleaned all round. Then go round again, with the like sweeping stroke downwards, always commencing each successive course a little higher than the upper stroke had extended, till the bottom be finished. This operation, if carefully performed, will frequently make very old paper look almost equal to new. Great caution must be used not by any means to rub the paper hard, nor to attempt cleaning it the cross or horizontal way. The dirty part of the bread, too, must be continually cut away, and the pieces renewed as soon as may become necessary.

410. To take Grease Stains out of Wall Papers. Oil marks, and marks where people have rested their heads, can be taken from the paper on drawing-room walls by mixing pipe-clay with water to the consistency of cream, laying it on the spot, and letting it remain till the following day, when it may be easily removed with a penknife or brush.

411. To take Grease from Paper. Gently warm the parts containing the grease, and apply blotting-paper so as to extract as much as possible. Boil some clear essential oil of turpentine and apply it to the warm paper with a soft clean brush. A little rectified spirits of wine should be put over afterward.

412. To take out Stains of Ink from Books. Oxymuriatic acid removes, perfectly, stains of ink; and should the paper require bleaching, the operation will answer both ends at the same time. Nearly all the acids will remove spots of ink from paper; but it is important to use such as do not attack its texture. Spirits of salt (muriatic acid) diluted in 5 or 6 times the quantity of water, may be applied with success upon the spot, and after a minute or two, washing it off with clean water. A solution of oxalic acid, citric acid, and tartaric acid, is attended with the least risk, and may be applied upon the paper and plates without fear of damage. These acids taking out writing ink, and not touching the printing, can be used for restoring books where the margins have been written upon, without attacking the text.

413. To Remove Yellow Stains from the Margins of Engravings. The yellow stains on the margin of engravings may be removed by a solution of hydrochloride of soda. This liquid is commonly known under the name of Labarraque's solution.

414. To Clean Silver or Gold Lace. Lay the lace smooth on a woolen carpet or piece of woolen cloth, and brush it free from dust, then burn rock alum and powder it fine, and afterwards sift it through a lawn sieve; then rub it over the lace with a fine brush, and in so doing it will take off the tarnish and restore it to its brightness, if it be not too much worn on the threads.

415. To Clean Papier Maché. Papier maché articles should be washed with a sponge and cold water, without soap, dredged with flour while damp, and polished with a flannel.

416. To Clean Hair Brushes and Combs. Wash the bristles for a few seconds in a weak solution of hartshorn, say a tablespoonful to a pint of cold soft water. Then rinse in clean cold water, and dry. Do not set them near the fire, nor in the sun, to dry, but, after shaking them well, set them on the point of the handle in a shady place. By this process the brush will be thoroughly cleansed with very little trouble. Observe that the mahogany or satin-wood back of the brush must be kept out of the solution, as it is apt to discolor wood. Combs may be cleaned in the same manner.

417. To Clean Looking Glasses. Take part of a newspaper, fold it small, dip it in a basin of clean cold water, and when it is thoroughly wet squeeze it out as a sponge, and then rub it hard over the face of the glass, taking care that it is not so wet as to rundown in streams. After the glass has been well rubbed with the wet paper, let it rest a few minutes and then go over it with a fresh dry newspaper, till it looks clear and bright, which it will do almost immediately. The inside of windows may be cleaned in this way, and they will look beautifully clear.

418. To Clean Straw Matting. Wash it with weak salt and water and dry it well, or boil a small bag of bran in 2 gallons of water, and wash the matting with the water, drying it well.

419. To Clean Cane-Bottom Chairs. Turn up the chair bottom, and with hot water and a sponge wash the canework well, so that it may become completely soaked. Should it be very dirty you must add soap. Let it dry in the open air if possible, or in a place where there is a thorough draught, and it will become as tight and firm as when new, provided it has not been broken.

420. To Clean Sheepskin Rugs or Mats. Make a very strong lather, by boiling soap in a little water; mix this with a sufficient quantity of water (rather more than lukewarm) to wash the mat or rug in, and rub boiled soap on those portions of it which require additional cleansing. When the mat has been well washed in this water, prepare another lather in the same way, in which a second washing must take place, followed by a third, which ought to be sufficient to cleanse it thoroughly. Rinse it well in cold water until all the soap is removed, and then put it in water in which a little blue has been mixed, sufficient to keep the wool of a good white, and prevent its inclining to yellow. After this it should be thoroughly wrung, shaken, and hung out in the open air with the skin part towards the sun, but not while it is scorching, otherwise the skin will become hard. It must also be shaken often while drying, for if not, it will be quite stiff and crackly. It should be frequently turned, being hung up first by one end and then by the other, until it has dried entirely.

421. To Clean Knives and Forks. Procure a smooth board, free from knots, or one covered with leather. If the latter, melt a sufficient quantity of mutton-suet, and put it hot upon the leather with a piece of flannel; then take two pieces of soft Bath brick, and rub them one against the other over the leather till it is covered with the powder, which rub in until no grease comes through when a knife is passed over the leather, which may easily be known by the knife keeping its polish. If only a plain board, rub the Bath brick 2 or 3 times over it; if too much be put on at once it will make the blades of the knives look rough and scratched. Let the board be of a proper height, and set so that the person may be a little on the stoop while cleaning the knives. Take a knife in each hand, holding them back to back; stand opposite the middle of the board; lay the knives flat upon it, and do not bear too hard upon them; by this method it will be easier to clean two knives at a time than one, and they will be less liable to be broken, for good knives will snap when pressed on too heavily. Many will say that they cannot clean two knives at once, or that they can get through them faster one by one; but if they will only try it a few times in the way recommended, they will find it not only much more expeditious, but easier. A little practice is all that is necessary.

The best way to clean steel forks is to fill a small barrel with fine gravel, brick dust, or sand, mixed with a little hay or moss; make it moderately damp, press it well down, and let it always be kept damp. By running the prongs of the steel forks a few times into this, all the stains on them will be removed. Then have a small stick, shaped like a knife, with leather round it, to polish between the prongs, having first carefully brushed the dust from them as soon as they are taken out of the tub. A knife-board is often spoiled in cleaning forks upon it, and likewise the backs of the knives; to prevent this, have a piece of old hat or leather put on the board where the forks and backs of the knives are cleaned.

422. To Preserve Knives and Forks in Good Condition. Wipe the knives and forks as soon as possible after being used, as the longer they are left with grease and stains on them the harder they will be to clean; particularly if they have been used for acids, salads, tarts, etc.; have then a jug of hot water ready to put them into as soon as done with, and wipe them as before directed.

In order to keep knives and forks in good condition when they are not in use, rub the steel part with a flannel dipped in oil; wipe the oil off after a few hours, as there is often water in it; or dust the blades and prongs with quicklime, finely powdered and kept in a muslin bag.

423. To Clean Spice Mills. It is often desired to grind different spices, orange or lemon peel, in the same mill, without any one being affected by another spice. Grind a teaspoonful of rice through the mill and all impurities will be removed. A coffee mill may be fitted to grind any spice in the same way, using rather more rice. The rice will of course be flavored by whatever may have been in the mill. It is useful to thicken soups, or gravies, or sauces, when the spice is no objection.

424. To Keep Oil-Cloths Looking Well. Wash them once a month in skim milk and water, equal quantities of each. Rub them once in three months with boiled linseed oil. Put on very little, rub it well in with a rag, and polish with a piece of old silk. Oil-cloths will last years if kept in this way.

425. To Clean Oil-Cloth. An oil-cloth should never be scrubbed with a brush, but, after being first swept, should be cleaned by washing with a soft flannel and lukewarm or cold water. On no account use soap, or water that is hot, as either would have a bad effect on the paint. When the oil-cloth is dry, rub it well with a small portion of a mixture of bees' wax, softened with a minute quantity of turpentine, using for this purpose a soft furniture polishing brush. Oil-cloth cared for in this way will last twice the time than with ordinary treatment.

426. To Give to Boards a Beautiful Appearance. After washing them very nicely with soda and warm water and a brush, wash them with a very large sponge and clean water. Both times observe to leave no spot untouched; and clean straight up and down, not crossing from board to board; then dry with clean cloths, rubbed hard up and down in the same way.

The floors should not be often wetted, but very thoroughly when done; and once a week dry-rubbed with hot sand and a heavy brush, the right way of the boards.

The sides of stairs or passages on which are carpets or floor-cloth, should be washed with sponge instead of linen or flannel, and the edges will not be soiled. Different sponges should be kept for the above two uses; and those and the brushes should be well washed when done with, and kept in dry places.

427. To Scour Boards. Lime, 1 part; sand, 3 parts; soft soap, two parts. Lay a little on the boards with a scrubbing-brush, and rub thoroughly. Rinse with clean water and rub dry. This will keep the boards of a good color, and will also keep away vermin.

428. To Clean Stone Stairs and Halls. Boil 1 pound of pipe-clay with a quart water, and a quart small beer, and put in a bit of stone-blue. Wash with this mixture, and, when dry, rub the stone with flannel and a brush.

429. To Clean Glass Globes. If the globes are much stained on the outside by smoke, soak them in tolerably hot water with a little washing soda dissolved in it; then put a tea-spoonful of powdered ammonia into a pan of lukewarm water, and with a tolerably hard brush wash the globes till the smoke stain disappears; rinse in clean cold water, and let them drain till dry; they will be quite as white and clear as new globes.

430. To Clean Decanters. There is often much difficulty experienced in cleaning decanters, especially after port wine has stood in them for some time. The best way is to wash them out with a little pearlash and warm water, adding a spoonful or two of fresh slaked lime if necessary. To facilitate the action of the fluid against the sides of the glass, a few small cinders may be used.

Or, soak the decanters for some hours in warm soda and water; if there is much cutting on the outside, a brush will be necessary to remove the dirt and stains from the crevices. Cut a potato into small dice, put a good handful of these into the decanter with some warm water, shake the decanter briskly until the stains disappear; rinse in clean cold water, and let them drain until dry. Vinegar and sauce cruets can be cleaned in the same way.

431. To Clean Glass Bottles. Chop up a large potato very fine and put it in the bottle with some warm water, and shake it rapidly until it is clean. Some use shot and soda, but potato is even more effectual.

432. To Clean Medicine Phials. Cleanse bottles that have had medicines in them, by putting ashes in each, immersing them in cold water, and then heating the water gradually till it boils. After boiling an hour, let them remain in the water till it is cold. Wash them in soap-suds, and rinse them till clean in clear water.

433. To Wash Castor Bottles. Put them ½ full of rice and fill up with warm water; shake them well; this will cleanse them thoroughly.

434. To Clean Greasy Earthenware. Stone pots and jars in which lard or fat has been kept, and yellow ware pie plates, may be cleaned by putting them in a kettle with ashes or sal soda, covering them with cold water, and allowing them to boil slowly an hour at least. When boiled enough, take them off the fire and leave them in the water until it cools.

435. To Clean Paint. There is a very simple method to clean paint that has become dirty, and if our housewives should adopt it, it would save them a great deal of trouble. Provide a plate with some of the best whiting to be had, and have ready some clean warm water and a piece of flannel, which dip into the water and squeeze nearly dry; then take as much whiting as will adhere to it, apply it to the painted surface, when a little rubbing will instantly remove any dirt or grease. After which wash the part well with clean water, rubbing it dry with a soft chamois. Paint thus cleaned looks as well as when first laid on, without any injury to the most delicate colors. It is far better than using soap, and does not require more than half the time and labor.

Another simple method is as follows:—put a table-spoonful of aqua ammonia in a quart of moderately hot water, dip in a flannel cloth, and with this merely wipe over the wood-work; no scrubbing will be necessary.

436. To Clean Varnished Paint. Boil a pound of bran in 1 gallon of water an hour, and wash the paint with the bran water.

437. To Clean Soiled Ribbons and Silks. A mixture of alcohol and *highly rectified* benzine is excellent for cleaning ribbons and silks. It is applied with a clean sponge. Persons who apply these liquids and mixtures to cleaning silks, &c., must be careful to do so in an apartment where there is neither fire nor lamp burning, under the penalty of an explosion. *(See No. 346.)*

438. To Remove Stains from Kid Gloves. Stains may be removed, even from the most delicately colored gloves, by suspending them for a day in an atmosphere of ammonia. Provide a tall glass cylinder, in the bottom of which place strong aqua ammonia. Be careful to remove from the sides of the jar any ammonia that may have been spattered upon them. Suspend the gloves to the stopper in the jar. They must not come in contact with the liquid.

439. To Clean Kid Gloves. Dr. Reimann gives the following directions, in the *Scientific American*, for cleaning kid gloves:—

A bottle 2 feet high, and 1 to 1½ feet wide, the stopper of which is also made of glass, is filled with 2 pounds of benzine. Then the gloves which are to be washed are put also into the bottle. On this account the neck of the bottle must be very wide, perhaps from ½ to ¾ foot in diameter. Such bottles are easily obtained, being much used in pharmacy. As many gloves may be introduced into the bottle as the liquid will cover. The bottle is then closed, well shaken, and allowed to stand some minutes. The shaking is repeated, the bottle opened, and the gloves taken out with a pair of iron forceps.

To prevent the possibility of there being any smell, it is a good plan to open the bottle under a good chimney, which thus carries off all the vapor that escapes.

The gloves, when brought by the forceps to the mouth of the bottle, are taken out, one after the other, by the hand, and wrung out, care being taken that the superfluous liquid runs back again into the bottle. It is highly advisable to perform this operation under a chimney, or the workman will soon suffer from the injurious influence of the volatile hydrocarbon.

Under the chimney is placed a cord stretched between two pins, and the gloves are hung upon this by means of small S-shaped hooks. After hanging a short time they will be dry.

The benzine contained in the bottle dissolves all the grease which adheres to the gloves, and the dirt which had been combined with the grease is consequently removed at the same time. The benzine remaining in the bottle assumes a dirty gray color during the process of washing.

When the benzine has become too dirty, it is put into a distilling apparatus, and distilled over. In this way the benzine is restored to its original purity and whiteness, so that it can be used again in further operations. *(For directions how to accomplish this, see next receipt.)*

The gloves, when taken out of the bottle, are often not quite clean, in which case it is necessary to rub them with a rag, moistened with benzine, in all places where they are still dirty.

Thus the last traces of dirt are removed, and the gloves become perfectly clean. In this state they may be hung on a cord under the chimney.

The gloves soon become dry, but a part of the benzine still remains behind, which is less volatile, and which, when the glove is in contact with the warm hand, causes a strong odor of benzine to be evolved.

To remove this also, the gloves are placed on a common plate, which is put upon an iron pot containing boiling water. The first plate is covered with a second, and the gloves between the two plates are heated at the boiling temperature of water, until the last traces of the unvolatilized benzine have escaped.

The gloves are now removed from the plate, and put upon a wooden glove-stretcher, or shape. In this way they are made to resume their original form, and are now ready for use.

The whole operation must be so conducted that no smell of benzine is perceptible. The smell of benzine is always a sign of carelessness on the part of the workman, who can readily conduct all the benzine vapors up the chimney. *(See No. 346.)*

440. To Re-Distill and Purify Benzine that has been used for Cleaning Kid Gloves. If the operation of distilling the benzine is disagreeable to the glove maker, he can have it purified at the apothecary's or chemist's. It is, however, an operation which he can readily perform himself

The apparatus is neither complicated nor expensive. A small wooden pail, such as is used in every establishment, is furnished with two holes. The first of these is drilled near the upper margin of the pail, so that, when the pail is filled with water, the water runs out through the hole, until the surface of the water within the pail is on a level with the lowest portion of the hole, that is to say, just below the upper margin of the vessel.

On the opposite side of the pail another hole is made, but this time near its bottom, so that water would run through this hole, until the surplus of the contained water was within a short distance of the bottom.

A leaden tube, the thickness of which equals the diameter of the hole, is bent so as to form a distilling worm, the upper end of which is inserted into the upper opening, and the lower end into the lower hole.

The tube is tightly inserted into both holes, so that no water can run through the space between the tube and the hole.

The pail is then filled with cold water.

The upper and lower ends of the leaden tube must project a little beyond the outer surface of the pail—perhaps two inches.

The lower end is bent downward a little. The upper end is a little enlarged, so that the tube forms a sort of funnel above.

In this is inserted a glass retort, conveniently fixed in a holder.

The space between the neck of the retort and the enlarged end of the leaden tube is conveniently filled with moistened cotton, so that no vapors can escape through it.

It is a good plan to employ a glass retort with a tube, so that any fluid can be poured into it when the apparatus is already fixed.

Having placed the retort on a vapor bath, where it can be heated at 212° Fahr., the neck of the retort is connected with the worm, as above mentioned, and the pail filled up with cold water. The retort is then filled with the impure benzine or petroleum essence which has been used in washing gloves.

After pouring in the benzine, the tube of the retort is closed by a stopper, and then the apparatus is completed by a bottle placed under the lower end of the leaden tube, which projects beyond the outer surface of the pail, so that the liquid running down this flows directly into the bottle.

The vapor bath is now heated, the retort soon becomes warm, and the volatile liquid begins to distill over, either quickly or slowly, according to the way in which the heating process is conducted.

The vapor of the hydrocarbon condenses in the worm, and a stream of liquid flows out of its mouth. In a short time there remains behind in the retort only the grease which the benzine has extracted from the gloves.

441. To Refine Ox-gall for Fixing Chalk and Pencil Drawings, and Removing Grease. Allow fresh ox-gall to repose for 12 or 15 hours, decant the clear, and evaporate to the consistence of a thick syrup, in a water-bath; then spread it *thinly* on a dish, and expose it before the fire, or to a current of dry air, until nearly dry. It will then keep for years in wide-mouthed bottles or pots, covered over with bladder. For *use*, a little is dissolved in water.

Or:—fresh gall, 1 pint; boil, skim, add pounded alum, 1 ounce; boil again until the alum is dissolved, and when sufficiently cool, pour it into a bottle, and loosely cork it down; in a similar manner boil and skim another pint of gall, and add to it 1 ounce of common salt; boil till dissolved, and cool and bottle as above. In three months decant the *clear* from both bottles, and mix them in equal quantities; the clear portion must then be separated from the coagulum by subsidence or filtration. It is employed by artists to fix chalk and pencil drawings before tinting them, and to remove the greasiness from ivory, tracing paper, &c. It is also used to extract grease and oil from clothes: for the latter purpose it answers admirably.

442. To Clean Cloth Clothes. Dissolve 4 ounces washing soda in 1 quart boiling water; when dissolved, add to it 1 moderate sized *fresh* beef's gall; lay the garment to be cleaned on a clean table or board, and with a sponge or brush (a brush is the best) wetted in the liquid, rub well the grease spots first, and afterwards the whole garment, frequently dipping the sponge or brush in the liquid; when sufficiently rubbed, rinse in cold water until the water is clear, then squeeze the water out thoroughly (but without twisting—if possible, use a patent wringer), shake well and hang in the air to dry. While drying, shake the garment occasionally and pull it into shape to prevent shrinking. When still slightly damp, press it on the wrong side with a warm iron, and then finish airing. Clothes cleaned in this way, if the directions be strictly followed, look almost equal to new. The use of the patent wringing machine is a great improvement in this operation, as it hastens drying, and prevents shrinking. The editor has used this receipt in his family for the last 15 years with the most satisfactory results. For dark-colored cloth garments, it is a common practice to add some fuller's earth to the mixture of soap and gall. When nearly dry, the nap should be laid right, and the garment carefully pressed, after which, a brush, moistened with a drop or two of olive oil, should be passed over it several times; this will give it a superior finish.

443. To Clean Woolen Clothes. Mix ½ ounce sulphuric ether and ½ ounce hartshorn (ammonia water) with 3 ounces water. Rub the article well with a sponge frequently wetted with the mixture, which will remove the dirt; then sponge with clean warm water; next lay a coarse towel, which has been saturated with hot water and wrung out, over the article, and press it with a hot iron; while the steam is still rising from the cloth, brush it down with a clothes brush.

444. To Clean Carpets. Carpets may be cleaned as follows: Take them up and shake and beat them, so as to render them perfectly free from dust. Have the floor thoroughly scoured and dry, and nail the carpet firmly down upon it. If still much soiled it may be cleaned in the following manner: Take a pailful of clean cold spring water, and put into it about 3 gills of ox-gall. Take another pail with clean cold water only. Now rub with a soft scrubbing brush some of the ox-gall water on the carpet, which will raise a lather. When a convenient sized portion is done, wash the lather off with a clean linen cloth dipped in the clean water. Let this water be changed frequently. When all the lather has disappeared, rub the part with a clean dry cloth. After all is done, open the window to allow the carpet to dry. A carpet treated in this way will be greatly refreshed in color, particularly the greens. Any particularly dirty spots should be rubbed by nearly pure gall first; and every spot of grease must be removed from the carpet by the following process: Scrape and pound together, in equal proportion, magnesia in the lump and fuller's earth. Having mixed these substances well together, pour on them a sufficient quantity of boiling water to make them into a paste. Lay this paste, as hot as possible, upon the grease spots upon the carpet, and let it dry. Next day, when the composition is quite dry, brush it off, and the grease spot will have disappeared. (*See No.* 357.)

445. To Clean Hearth Rugs and Stair Carpets. Hearth rugs and stair carpets may be treated in the same manner as given in the last receipt, only that these may be spread and washed upon a table.

446. How to Clean Carpets. Carpets may be washed on tables or on the floor. In either case they must be taken up and well beaten and swept. Grease is taken out by rubbing hard soap on the spot, and scrubbing it out with a brush dipped in clean cold water. Each spot must be rubbed dry with a cloth as it is washed. Dissolve a bar of soap in 2 gallons of water, by cutting it into the water and heating to a boil. Lay the carpet on the floor and tack it down, or have a heavy board, 3 feet wide by 12 feet long, laid on stout stands, or horses, and throw the carpet over that, keeping a clean board or sheet underneath to receive the carpet as it is cleansed. Provide brushes, and a quantity of coarse cotton cloths, flannels, and a large sponge. Take 2 pails filled with blood-warm water, put 2 quarts of the melted soap into one of them to scour the carpet with, and use the other for rinsing. Dip the brush in the soap-suds, and scour a square yard of the carpet at a time, using as little water as possible, not to soak it through. When the soap has done its work, rub it well out of the carpet with a flannel or coarse sponge, sucking up with these all the wet and dirt left by the brush, rinsing the article used in clean water repeatedly. Have ready a pail of clean cold water, with enough sulphuric acid or sharp vinegar in it to taste sour; dip a clean sponge in this, squeeze and rub it well into the spot just cleansed. Afterward wipe dry with coarse cloths, rinsing and hanging them where they will be dry when the next yard is washed. Finish yard after yard in this way, rubbing each clean and dry as you go. Keep a good fire in the room to dry the carpet thoroughly. If scoured on a frame, nail the carpet against the side of a house in the sun to dry. This is a tedious, but thorough process. Hearth rugs may be cleaned in the same way, beating and brushing them well, and tacking on a large board before washing. Scrub one-sixth of it at a time unless you are expeditious, and dry well with an old sheet. The secret of having carpets look well is to wash and rinse them thoroughly, without soaking them through. Ingrain, tapestry, Brussels, and Turkish carpets are all cleaned in this way. Good authorities recommend a tea-cupful of ox-gall to a pail of soap-suds, rinsing with clean water. (*See No.* 444.)

447. To Sweep Carpets. Before applying the broom, scatter over the carpet the refuse tea-leaves from the tea-pot. These should be set apart and saved in a pot kept for the purpose, squeezing the water out thoroughly in the hand. First rub the leaves into the carpet with the broom, and then sweep as usual. This will prevent dust and brighten the colors. Indian meal is recommended for this purpose by many experienced housekeepers.

448. To Clean Colored Silks, Moreens, Chintzes, and Printed Cottons. Colored or black silks, moreens, printed cottons, and chintzes, may be cleaned, without injury to their colors, by potato liquor. Grate raw potatoes to a fine pulp; add water in the proportion of 1 pint to 1 pound of potatoes; pass the liquid through a coarse sieve into a vessel, and allow it to remain till the fine white starch subsides to the bottom. Pour off the clear liquor, which is to be used for cleaning. Spread the article to be cleaned upon a table, which should be covered with a linen cloth; dip a sponge in the liquor, and apply it until the dirt is removed. Then rinse the article in clean cold water several times.

449. To Clean Old Tapestry on the Wall. Old tapestry is cleaned on the wall, beginning at the top. Melt a bar of good common soap in a gallon of water, and put 1 quart of it in a gallon of cold water. A clothes brush of fine broom straw or long bristles is best to dust with; a soft brush, piece of wash-leather, some flannels, and dry sheets are also needed. Brush all dust from the tapestry first, cleaning the corners well. Dip a flannel in the suds, squeeze it slightly, rub the tapestry to a lather, and brush well with a soft brush. Wring the flannel out of the soap, and rub the tapestry dry with it and wash-leather; lastly wiping the whole as dry as possible with a sheet, as it must not be rinsed. Melt 4 ounces of tartaric acid in a pint of boiling water, and add to it 2 gallons of clean water. Squeeze a clean sponge in this acid, and rub it well into the place just cleaned and dried; then finish with the dry sheet at once before going to the next yard of surface. Renew the suds and rinsing water frequently, as well as the towels, flannels, etc., for everything must be used clean. A good fire should be kept in the room when tapestry is cleaned. When dry, rub a lump of pipe-clay well into it, and brush it out with a good clothes brush. This takes the soap out and brightens the colors. Worsted work may be cleaned in this way.

450. To Clean Silk and Cotton, or Silk and Worsted Damask, Terry, or Brocatelle Curtains. Silk and cotton, or silk and worsted damask, terry, or brocatelle curtains, are cleaned over a board by scrubbing with ¼ a gallon camphene and a brush, first dipping the curtain into the camphene, then cleaning on the wrong side, and lastly on the right. Dip it again into the camphene just used, and rinse in the same amount of fresh camphene. Let it drain a minute, then wipe it off with a linen or cotton sheet till all the moisture possible is absorbed, and brush it with a dry brush of soft hair. Hang them in the air a few hours to take away the smell of camphene. 1 gallon is enough for each curtain width. Next roll the curtains in half-dry sheets to damp them; take them out; brush and rub them; then iron, with a damp cloth laid over them, and they will look like new.

451. To Clean Worsted Reps. Worsted rep sofas, and worsted furniture of any kind, are freshened by dusting damp Indian meal over them, and rubbing off with a stiff brush. Dry bran is said to answer the same purpose, or very light, dry snow, not suffered to melt on the surface. A large sheet should be spread under each piece of furniture, as it is cleaned, to catch the falling litter.

452. To Clean Table-Covers of Cotton and Worsted, Silk and Worsted, or Printed Cloth. Dissolve 1 bar of the best mottled soap in 4 gallons of scalding water, with 1 pound of pearlash in it. Have 3 tubs ready, and put in the first, 1 pail of cold water and 3 gallons of soap liquor; in the second, 1 pail of cold water and 2 gallons of soap liquor; and in the third, 2 pails of cold water and 1 gallon of soap liquor. In another tub have 6 pails of cold water, with a table-spoonful of oil of vitriol in it. If the cover is cotton and worsted, wash and wring it through the three soap-waters; rinse it five minutes in the vitriol tub, and wring out of cold, clear water; fold it up smoothly to drain, and hang it to dry without wringing.

For a silk and worsted cover use three soap-waters; rub it well, and, instead of the vitriol, put a pound of common salt in 2 pails of water, and work the cloth well in this. Rinse it in 2 cold waters after the salted one, and hang it to dry in a warm room.

A printed cloth wash through three soap-liquors; if one has a variety of table-cloths, of different mixtures, they may be put through the same suds in the order given in these directions, using different rinses for each. Give the printed cloth, after the last soap-liquor, two cold waters, with a table-spoonful of vitriol in each; after these, a cold, clear water. Fold and drain it, and dry quickly in a warm room, or the colors will run into one another. To press table-cloths, lay them under a damp sheet, and iron with a heavy iron.

453. To Clean White Jean Boots. If you have not boot-trees, stuff the boot as full as possible with common cotton wadding or old rags, to prevent any creases; then mix some pipe-clay with water to rather a stiff paste, wash the jean boots with soap and water and a nail brush, using as little water as possible to get the dirt off. When they look tolerably clean, rub the pipe-clay with a flannel well over them and hang them to dry. When dry, beat out the superfluous clay with the hand and rub them till they look smooth. Flake white may also be used.

454. To Clean White Kid Boots. If the kid boots are not very soiled they may be cleaned in the following manner: Put ½ ounce of hartshorn into a saucer, dip a bit of clean flannel in it and rub it on a piece of white curd soap; rub the boots with this, and as each piece of flannel becomes soiled, take a fresh piece; the boots will look like new.

455. To Clean White Satin Shoes. White satin shoes may be cleaned by rubbing them with stone blue and flannel, and afterwards cleaning them with bread.

456. To Clean Black, and Other Silks, with old Kid Gloves. Cut up a black kid glove in small pieces and pour a pint of boiling water over it. Cover it and let it stand all night where the water will keep warm if possible. In the morning let it boil up, strain it, and add 1 dessert-spoonful of alcohol. Keep it warm while sponging the silk on the *right* side and iron immediately on the *wrong* side. For light silks use white or light kid gloves. It will do without the alcohol, but is better with it.

457. To Clean Black Silks. Steep a few hours in cold water. Then put ½ a pint of the *Black Reviver* in ½ a gallon of water, and a cupful of ox-gall. Make hot, and sponge the silk. Dry and smooth with an iron. (*See next receipt*).

Rusty black silk may be cleaned in the same way. Some persons clean black silk by rubbing it with a flannel dipped in gin.

458. Black Reviver, to Restore the Color of Black Silk, Cloth or Leather. Take of blue galls, bruised, 4 ounces; logwood, copperas, iron filings free from grease, and sumach leaves, each 1 ounce. Put all but the iron filings and copperas into 1 quart good vinegar, and set the vessel containing them in a warm water bath for twenty-four hours, then add the iron filings and copperas and shake occasionally for a week. It should be kept in a well-corked bottle. It may be applied to faded spots with a soft sponge. It is good also to restore the black color of leather when it turns red, the leather being previously well cleaned with soap and water.

459. To Restore Black Silk. To ox-gall, add boiling water sufficient to make it warm, and with a clean sponge rub the silk well on both sides; squeeze it well out, and proceed again in like manner. Rinse it in spring water, and change the water till perfectly clean; dry it in the air, then dip the sponge in glue-water, and rub it on the wrong side; pin it out on a table, and dry before a fire.

460. To Clean Silks, Satins, Colored Woolen Dresses, &c. 4 ounces of soft soap, 4 ounces of honey, the white of an egg, and a wine-glassful of gin; mix well together, and scour the article (which must be unpicked, and laid in widths on a kitchen table) with a rather hard brush, thoroughly; afterwards rinse it in cold water, leave to drain, and iron whilst quite damp, with a piece of thin muslin between it and the iron, or it will be marked on the ironed side. The silk, when laid on the table, must be kept quite smooth, so that every part may come under the brush. White silk requires a little blue in the water. This receipt is an excellent one.

461. To Raise the Nap on Cloth. Soak in cold water for ½ an hour, then put on a board, and rub the threadbare parts with a half-worn hatter's card, filled with flocks, or with a prickly thistle, until a nap is raised. Hang up to dry, and with a hard brush lay the nap the right way.

462. To Renovate Black Crape. Skim-milk and water, with a little bit of glue in it, made scalding hot, will restore old rusty black Italian crape. If clapped and pulled dry, like fine muslin, it will look as good as new.

463. To Raise the Pile on Velvet or Plush. Hold the wrong side of the velvet over the steam arising from boiling water, until the pile rises—or dampen lightly the wrong side of the velvet and hold it over a pretty hot iron, not hot enough to scorch, however: or, make a clean brick hot, place upon it a wet cloth, and hold the velvet over it, and the steam will raise the plush.

464. To Restore Creased Ribbons. Creased ribbons may be restored by laying them evenly on a board, and with a very clean sponge damping them evenly all over. Then roll them smoothly and tightly on a ribbon block, of greater breadth than the ribbon, and let them remain until dry. Afterwards transfer to a clean dry block. Then wrap in *brown* paper, and keep until wanted.

465. To Wash China Crape Scarfs. If the fabric be good, these articles of dress can be washed as frequently as may be required, and no diminution of their beauty will be discoverable, even when the various shades of green have been employed among other colors in the patterns. In cleaning them, make a strong lather of boiling water, suffer it to cool; when cold, or nearly so, wash the scarf quickly and thoroughly, dip it immediately in cold hard water in which a little salt has been thrown (to preserve the colors); rinse, squeeze, and hang it out to dry in the open air; pin it at its extreme edge to the line, so that it may not in any part be folded together. The more rapidly it dries the clearer it will be.

466. To Wash a Black Lace Veil. Mix bullock's gall with sufficient hot water to make it as warm as you can bear your hand in, and pass the veil through it. It must be squeezed, not rubbed; and it will be well to perfume the gall with a little musk. Rinse the veil through two cold waters, tinging the last with a little blue. After drying, put it into some stiffening made by pouring boiling water on a very small piece of glue; squeeze it out, stretch it, and clap it. Afterwards, pin it out on a linen cloth to dry, laying it very straight and even, and taking care to open and pin the edge very nicely. When dry, iron it on the wrong side, having laid a linen cloth over the ironing blanket.

Any article of black lace may be washed in this manner.

467. To Wash White Silk Stockings. Heat some rain or soft water, and while on the fire cut into it slices of good yellow soap, to make a lather; put the stockings in while the lather is warm, but not scalding, and wash them in two such waters (a wine-glassful of gin in the first water is an improvement); rinse them well in lukewarm water, having ready a second rinsing water, in which is mixed a little blue (not the common kind, but such as is used for muslins and laces), or rose pink, which can be procured at the chemist's, and is used in the same way as the blue, by tying it up in a piece of flannel and squeezing it into the water. After rinsing, put the stockings between towels and let them get almost dry; place them on a small sheet, lay them out quite flat, as they are when first purchased, tack them to the sheet with a needle and thread, turn the sheet over them, and have them mangled. If it is not convenient to have them mangled (run between weighted rollers), the next best plan is to put four or six stockings one upon the other between a piece of muslin, lay them on a stone doorstep, and beat them with the rolling pin. They must not be mangled or beaten in towels, as the pattern of the towels would be impressed on them. If the stockings have lace fronts they will more particularly require the tacking mentioned above to make them look nice. No soda or washing powder of any kind must be put to them, and they must be done quickly, and not left lying about.

468. To Clean Soiled Bed Ticks. Apply starch by rubbing it in thick with a wet cloth, then put the tick in the sun. When dry, rub it with the hands. If necessary, repeat the process, and the soiled part will be as clean as new.

469. To Restore the Gloss Finish on Woolen Goods, removed by Washing. Brush the cloth over, *the way of the cloth*, with a brush wetted with very weak gum-water; lay over it a sheet of paper or a piece of cloth, and put it under a weight or in a screw-press until dry. This will restore the original gloss to the dull spot often left after washing out a stain.

470. To Remove Stains from Black Crape and Mourning Dresses. Boil a handful of fig-leaves in 2 quarts of water, until reduced to a pint. Squeeze the leaves, strain the liquor, and put it into a bottle for use. Bombazines, crape, cloth, &c., should be rubbed with a sponge dipped in this liquor, and most stains will be instantly removed.

471. To Clean a White Lace Veil. Boil the veil gently for 15 minutes in a solution of white soap; put it into a basin holding warm water and soap, and keep gently squeezing it (do not rub it) till it is clean, and then rinse it from the soap. Then take a vessel of cold water, into which put a drop or two of chemic (*see No.* 162) or liquid blue; rinse the veil in it. Have ready some very clear gum arabic water, or some thin rice-water. Pass the veil through it. Then stretch it out even, and pin it to dry on a linen cloth, making the edge as straight as possible; opening out all the scallops, and fastening each with pins. When dry, lay a piece of thin muslin smoothly over it, and iron it on the wrong side.

472. To Wash White Silk Lace or Blond. Take a black bottle covered with clean linen or muslin, and wind the blond round it (securing the ends with a needle and thread), not leaving the edge outward, but covering it as you proceed. Set the bottle upright in a strong cold lather of white soap and very clear soft water, and place it in the sun, having gently with your hand rubbed the suds up and down on the lace. Keep it in the sun every day for a week, changing the lather daily, and always rubbing it slightly when you renew the suds. At the end of the week, take the blond off the bottle, and (without rinsing) pin it backward and forward on a large pillow covered with a clean tight case. Every scallop must have a separate pin; or more, if the scallops are not very small. The plain edge must be pinned down also, so as to make it straight and even. The pins should be of the smallest size. When quite dry, take it off, but do not starch, iron, or press it. Lay it in long loose folds, and put it away in a pasteboard box.

Thread lace may be washed in the same manner.

473. To Clean Thread Lace. Thread lace may be cleaned in the same manner as in last receipt. Or, when the thread lace has been tacked to the bottle, take some of the best sweet oil and saturate the lace thoroughly. Have ready in a wash-kettle, a strong cold lather of clear water and white Castile soap. Fill the bottle with cold water, to prevent its bursting, cork it well and stand it upright in the suds, with a string round the neck secured to the ears or handle of the kettle, to prevent its shifting about and breaking while over the fire. Let it boil in the suds for an hour or more, till the lace is clean and white all through. Drain off the suds and dry it on the bottle in the sun. When dry, remove the lace from the bottle and roll it round a white ribbon-block; or lay it in long folds, place it within a sheet of smooth white paper, and press it in a large book for a few days.

In washing laces, put 12 drops aqua ammonia in warm suds.

474. To Prepare Silks for Washing. Most colors are really improved by the following method, especially red, purple, orange, blue, olive, puce, &c. The more delicate greens are not improved, neither are they injured. This is likewise the case with lavender. If the silk is to be washed in a dress, the seams of the skirt do not require to be ripped apart, though it must be removed from the band at the waist, and the lining taken from the bottom. Trimmings, or furniture where there are deep folds, the bottom of which is very difficult to reach, should be undone so as to remain flat.

475. To Wash Silks. The article should be laid upon a clean smooth table. A flannel should be well soaped, being made just wet with lukewarm water, and the surface of the silk rubbed one way, being careful that this rubbing is quite even. When the dirt has disappeared, the soap must be washed off with a sponge, and plenty of cold water, of which the sponge must be made to imbibe as much as possible when the washing is done. As soon as one side is finished, the other must be washed precisely in the same manner. Let it be understood that not more of either surface must be done at a time than can be spread perfectly flat upon the table, and the hand can conveniently reach; likewise the soap must be quite sponged off one portion, before the soaped flannel is applied to another portion. The treatment of silks, after they have been thus washed, will be described hereafter. (*See next receipt.*)

Satin ribbons, both white and colored, and even satin dresses, may be cleansed with good effect by this process, which is likewise very effective in renovating all kinds of silk ribbons and trimmings.

476. To Stiffen Silk for Trimmings. Sponge the surface of the silk with a weak solution of gum arabic, or with equal parts of ale and water, and iron, while damp, on the wrong side. This is excellent when old silk is to be used for trimming, and it is necessary to keep it stiff.

477. To Wash Silk Pocket Handkerchiefs. Silk pocket handkerchiefs require to be washed by themselves, and those containing snuff should be put to soak in separate lukewarm water. Two or three hours after, they should be rinsed out and put to soak with the others in cold water for an hour or two. They should then be washed out in lukewarm water, being soaped as they are washed. If all the stains are not out of them, they must be washed through a second water of the same description. When finished, they should be rinsed in cold soft water, in which a handful of common salt has been dissolved. They may be rinsed all together, being thrown, as fast as they are washed, into a dry tub, whence, when all are done, they are transferred to the rinsing tub.

478. To Wash Point Lace. By following the directions laid down in this receipt, ladies may wash and finish their own point lace as thoroughly as any French laundress. Mix a tea-spoonful powdered borax in a basin of strong white Castile soap-suds. Baste the lace to be washed, very carefully, with *fine* cotton, upon two thicknesses of flannel. Soak the lace, thus arranged, in the soap-suds mixture for 24 hours, or longer if very dirty, changing the suds two or three times. Then let it lie for 2 or 3 hours in clean water to rinse, changing the water once. *Squeeze* it out (do not wring it), and, when partially dry, place the flannel with the lace on it, face downwards, on two thicknesses of dry flannel laid on a table, and smooth it with a hot iron. During the whole process, the lace must remain basted on the flannel; and when it is pressed, must lie sandwiched between the dry and damp flannel, and pressed upon the latter. When the lace is perfectly dry, rip it off.

479. Twelvetree's Washing Fluid for White Linen and Cotton Articles. Set aside the flannels and colored things, as they must not be washed in this way, then select from the clothes to be washed, all the coarse and dirtiest pieces from the fine; then put them in separate tubs of soft water to soak over night (the night previous to washing.) Then prepare in a separate vessel, the liquid for a large washing, namely, ½ pound of good brown soap, cut in small pieces; ¼ pound soda, and 3 ounces fresh, unslacked lime, mixed in 1 gallon of boiling soft water. Stir well up, so as to mix the ingredients, and let it stand until morning. Then strain off the liquid, being careful to leave all sediment behind. Having ready about 10 gallons of boiling soft water in the boiler, pour in the prepared liquid (keeping out all settlings that may yet be remaining) then throw in your clothes and boil them twenty minutes or half an hour. Previous to which, put an earthen plate at the bottom of the boiler, to prevent the clothes from burning. After boiling the appointed time, take them out; scald them, blue them, and rinse them in clean soft water, warm or cold, and the clothes will be as clean and white as snow. By this method, the finest linens, laces, cambrics, etc., can be readily and easily cleansed with very little trouble.

Should there be only a small washing, and less than 10 gallons of water required to boil them in, less of the liquid of lime, soap, and soda, can be used in proportion. When there is any difficulty in procuring fresh lime, a quantity of the liquor may be made at once from the lime, which will keep for years, corked in bottles, and ready for use.

480. Bingham's Patent Wash Mixture. Take 5 pounds of bar soap, shave fine, add 1 quart of lye, ½ ounce pearlash, dissolved over a slow fire. When dissolved, put into a vessel prepared for it to stand in; then add ½ pint turpentine, 1 gill hartshorn; stir well, and it is ready for use.

481. To Make Washing Fluid. To 1 gallon of common soft soap, (such as is made by the usual method of boiling the lye of wood ashes and fat together), take 4 ounces sal-soda, ½ gallon rain or soft water, and ½ gill spirits of turpentine; place them all in a pot over the fire, and allow the mixture to boil a few minutes; it is then ready for use, and can be kept in any earthen or stoneware vessel.

482. Washing Made Easy. The washerwomen of Holland and Belgium, so proverbially clean, and who get their linen so beautifully white, used refined borax as washing powder instead of soda, in the proportion of ½ a pound of borax powder to 10 gallons of water. They save soap nearly one half. All the large washing establishments adopt the same mode. For laces, cambrics, etc., an extra quantity of powder is used; and for crinolines (requiring to be made stiff) a stronger solution is necessary. Borax, being a neutral salt, does not in the slightest degree injure the texture of the linen. Its effect is to soften the hardest water, and therefore it should be kept on the toilet table.

483. White Lye for Washing. This is made by pouring a pailful of boiling water over 4 or 5 quarts of ashes. Let it stand a while to infuse; then pour in cold water to settle it, when you can pour it off clear. This is very good to boil dirty clothes in. When made nice, is equal to soda, and does not, unless made extremely strong, injure the clothes.

484. To Wash Linen in Salt Water. Drop into sea water a solution of soda or potash. It will become milky, in consequence of the decomposition of the earthy salts, and the precipitation of the earths. This addition renders it soft, and capable of washing. Its milkiness will have no injurious effect.

485. To Wash an Alpaca, Mousse-line-de-Laine, or Lama Dress that has Bright or Delicate Colors. Boil 1 pound best rice in 1 gallon water for three hours. When boiled, pour off what will be sufficient to starch the dress; wash the dress well in the remainder, rice and all, using the rice for soap; rinse it in clean cold water, wring it well, then starch it with the rice water that was kept for that purpose, and hang it before the fire to dry. When dry enough, iron with a cool iron, as it is liable to scorch. If some parts of the dress get too dry, they must be damped with a wet cloth whilst ironing. No soap must be used. The best way is to boil the rice on the previous day, and merely warm it up the next morning, for then you have the day before you to complete the whole, as the dress must on no account lie damp, even for an hour, or the colors will be sure to run. This receipt will be found equally well suited to delicate painted muslins and piqués as to lama and alpaca dresses.

486. To Wash Colored Muslins. In washing colored muslins and linens, there are several very essential points to be observed, whereby the colors are preserved from injury. In the first place, they should not be soaped or soaked over night, as the more delicate of the hues would be deteriorated by such process. When ready for washing, they should, if not too dirty, be put into *cold* water and washed up very speedily; if very dirty, the water may be lukewarm and no more. But above all, be careful not to use the smallest particle of soda. The best soap for washing articles made of this material is the common yellow. It is much better than the mottled, because it is less harsh, and removes the dirt in a shorter period. A small piece of alum should be boiled in the water in which the lather is made. The soap should not be allowed to remain any time on the linen; the latter should be soaped and washed as rapidly as possible, and not lie in the water any length of time. One article should therefore be washed at a time, and immediately rinsed through two cold waters, the others remaining in a dry state by the side of the tub until they are taken to be washed each in its turn. The liquid in which the articles are to be rinsed in succession immediately as they are washed, should consist of 3 or 4 gallons of cold soft water, with a handful of table salt dissolved in it. Should alum not be added to the lather, then a tea-spoonful of vinegar should be stirred into the water for each rinsing; this will help to fix and brighten the colors. The moment an article is taken from the rinsing tub, it should be wrung very gently, being twisted as little as can be helped. After rinsing, they should be hung out immediately to dry.

487. To Preserve the Colors of Merino, Mousselines-de-Laine, Gingham, Chintz, and Printed Lawns. Before washing almost any colored fabrics, it is recommended to soak them for some time in water to every gallon of which is added a spoonful of ox-gall. A tea-cup of lye in a pail of water is said to improve the color of black goods, when it is necessary to wash them. A strong clean tea of common hay will preserve the color of French linens. Vinegar in the rinsing water, for pink or green, will brighten those colors, and soda answers the same end for both purple and blue.

The colors of the above fabrics may be preserved by using a strong milk-warm lather of white soap, and putting the dress into it, instead of rubbing it on the material, and stirring into a first and second tub of water a large table-spoonful of ox-gall. (*See No. 489.*)

488. Hints for Washing Colored Clothes. No colored articles should ever be boiled or scalded. Neither should they be allowed to freeze, or the colors will be irreparably injured. They should be ironed immediately they are dry enough, and not be allowed to lie damp over night, nor be sprinkled. They should not be smoothed with a *hot* iron. Pink and green colors, though they may withstand the washing, will frequently change as soon as a *hot* iron is put over them.

489. To Prepare Ox-gall for Washing Colored Articles. Empty the gall in a bottle, put in it a handful of salt, and keep it closely corked. A tea-cupful to 5 gallons of water will prevent colored articles from fading.

490. The French Method of Washing Colored Muslins, Piqués, &c. Prepare some rather warm (not hot) lather, made with soft water and the best white soap; wash the dresses one at a time, but do not soak them. As soon as the first lather looks soiled, squeeze the dress from it, and at once wash it again in a fresh lather. When thoroughly clean, rinse in pure cold water, lastly in water slightly blued; squeeze (not wring) the water completely from the dress, and hang it in a shaded place to dry; if wet weather, dry it by the fire. The best prints will fade if hung in the sunshine.

491. To Render the Colors of Cotton Fabrics Permanent. Dissolve 3 gills of salt in 4 quarts of water; put the calico in while hot, and leave it till cold, and in this way the colors are rendered permanent, and will not fade by subsequent washing.

492. To Wash Chintz, so as to Preserve its Gloss and Color. Take 2 pounds of rice and boil it in 2 gallons of water, till soft; when done, pour the whole into a tub; let it stand and cool till about the usual warmth for colored linens; put the chintz in, and use the rice instead of soap; wash it in this till the dirt appears to be out; then boil the same quantity as above, but strain the rice from the water, and mix it in warm water. Wash it in this till quite clean; afterwards rinse it in the water the rice was boiled in; this will answer the end of starch, and no dew will affect it, as it will be stiff while it is worn. If a dress, it must be taken to pieces, and when dried, hang it as smooth as possible; when dry, rub it with a smooth stone, but use no iron.

493. To Wash Flannels or other Woolen Articles. Have the suds ready prepared by boiling up some good white soap in soft water, but do not use the suds when boiling; let them be as hot as the hand will bear when the articles are put in. The flannels should not be rubbed with soap, nor should the material itself be rubbed, as in washing linen, &c., rubbing knots the fibres of the wool together; hence the thickening of the fabric and consequent shrinking in its dimensions. Sluice the articles up and down in plenty of suds, which afterwards squeeze (not wring) out. The patent clothes-wringers are a great improvement upon hand labor, as, without injury to the fabric, they squeeze out the water so thoroughly that the article dries in considerably *less* time than it would do even after the most thorough hand wringing. After rinsing, squeeze out the water, and dry in the open air, if the weather is such as to admit of the articles drying quickly; if not, dry in a warm room, but avoid too close proximity to a fire. Let any dust or mud be beaten out or brushed off prior to washing.

All flannels should be soaked before they are made up, first in cold and then in hot water, in order to shrink them.

494. To Shrink Flannel. Flannel should be soaked in cold hard water before making, and hung up to drain and dry without any squeezing or handling in the water. After this it will not shrink in washing. Fill a tub with spring water, place the flannel in it, and take out as soon as it sinks to the bottom. It does not lose the appearance of new flannel when dry.

495. To Wash Red Flannel. To wash red or scarlet flannel when soiled, mix a handful of flour in a quart of cold water, and boil ten minutes. Add this to some warm suds, and wash the flannel gently; rinsing rather than rubbing it (*see No. 493*), rinse it in three or four warm waters, and the brightest scarlet will never lose its color. Soft soap or olive soap should be used for woolen goods in preference to bar soap.

496. Scotch Method of Washing Woolen Shawls. Scrape 1 pound soap, boil it down in sufficient water. When cooling, beat it with the hand; it will be a sort of jelly. Add 3 table-spoonfuls spirit of turpentine, and 1 of spirit of hartshorn. Wash the articles well in it, then rinse in cold water until all the soap is taken off, then in salt and water. Fold between two sheets, taking care not to allow two folds of the article washed to lie together. Iron with a very cool iron. Shawls done in this way look like new. Only use the salt where there are delicate colors that may run.

497. To Make Starch for Linen, Cotton, &c. To 1 ounce of the best starch add just enough soft cold water to make it (by rubbing and stirring) into a thick paste, carefully breaking all the lumps and particles. When rubbed perfectly smooth, add nearly or quite a pint of boiling water (with bluing to suit the taste), and boil for at *least half an hour*, taking care to stir it well all the time, to prevent its burning. When not stirring, keep it covered, so as to protect it from dust, etc. Also keep it covered when removed from the fire, to prevent a scum from rising upon it. To give the linen a fine, smooth, glossy appearance, and prevent the iron from sticking, add a little spermaceti (a piece as large as a nutmeg) to the starch, when boiling, and ½ a tea-spoonful of the finest table-salt. If you have no spermaceti, take a piece of the purest, whitest hog's lard, or tallow (mutton is the best), about as large as a nutmeg, or twice this quantity of the best refined loaf sugar, and boil with the starch. In ironing linen collars, shirt bosoms, etc., their appearance will be much improved by rubbing them, before ironing, with a clean white towel, dampened in soft water. The bosom of a shirt should be the last part ironed, as this will prevent its being soiled. All starch should be strained before using.

498. Gum Arabic Starch for Making Shirt-Bosoms Glossy. Procure 2 ounces of fine white gum arabic, and pound it to powder. Next put it into a pitcher, and pour on it a pint or more of boiling water, according to the degree of strength you desire, and then, having covered it, let it set all night. In the morning, pour it carefully from the dregs into a clean bottle, cork it, and keep it for use. A table-spoonful of gum water stirred into a pint of starch that has been made in the usual manner, will give a beautiful gloss to shirt-bosoms, and to lawns (either white or printed) a look of newness to which nothing else can restore them after washing. It is also good (much diluted) for thin white muslin and bobbinet.

499. To Make Starch for Colored Articles. For starching muslins, ginghams, and calicoes, dissolve and add to every pint of starch, a piece of alum the size of a shellbark. By so doing, the colors will keep bright for a long time, which is very desirable when dresses must be often washed, and the cost is but a trifle.

500. To Starch Muslins and Piqués. In getting up muslins and piqués, the failure is not generally in the washing, but in the starching. A good-sized panful of starch should be used, in which 3 or 4 inches of spermaceti candle has been melted whilst hot. The articles should be thoroughly squeezed from the starch, and folded whilst wet, between folds of old sheeting or table linen. They should then be passed through a wringing machine. All lumps of starch are thus removed.

Piqués should be ironed as lightly as possible, and the iron ought never to come into contact with the outside surface of the piqué. An old cambric handkerchief is the best thing to use under the iron where absolutely necessary to iron on the right side.

501. To Clear-starch Lace, Cambric and Book Muslin. Starch for laces should be thicker and used hotter than for linens. After the laces have been well washed and dried, dip them into the thick hot starch in such a way as to have every part properly starched. Then wring all the starch out of them, spread them out smooth on a piece of linen, roll them up together, and let them remain for about half an hour, when they will be dry enough to iron. Laces should never be clapped between the hands, as it injures them. Cambrics do not require so thick starch as net or lace. Some people prefer cold or raw starch for book-muslin, as some of this kind of muslin has a thick, clammy appearance if starched in boiled starch. Fine laces are sometimes wound round a glass bottle to dry, which prevents them from shrinking.

502. To Fold Clothes after Drying on the Line. Fold the fine articles and roll them in a towel, and then fold the rest, turning them all the right side outward. Lay the colored articles separate from the rest. They should not remain damp long, as the colors might be injured, and starched fabrics are apt to mildew. Sheets and table linen should be shaken and folded.

503. To Iron Clothes. In ironing a shirt, first do the back, then the sleeves, then the collar and bosom, and then the front. Iron calicoes generally on the right side, as they thus keep clean for a longer time. In ironing a frock, first do the waist, then the sleeves, then the skirt. Keep the skirt rolled while ironing the other parts, and set a chair to hold the sleeves while ironing the skirt, unless a skirt-board be used. Silk should be ironed on the wrong side, when quite damp, with an iron which is not very hot, as light colors are apt to change and fade. In ironing velvet, turn up the face of the iron, and after dampening the wrong side of the velvet, draw it over the face of the iron, holding it straight; always iron lace and needlework on the wrong side, and put them away as soon as they are dry.

504. To Restore Scorched Linen. It is almost needless to premise that if the tissue of linen is so much burnt that no strength is left, it is useless to apply the following composition; for nothing could prevent a hole from being formed, although the composition by no means tends to injure the fabric. But if the scorching is not quite through, and the threads not actually consumed, then the application of this composition, followed by two or three good washings, will restore the linen to its original color; the marks of the scorching will be so totally effaced as to be imperceptible, and the place will seem as white and perfect as any other part of the linen. *Mix well together* 2 ounces fuller's earth reduced to a powder; 1 ounce hen's dung; ¼ ounce of cake soap, scraped; and the juice of 2 large onions, obtained by the onions being cut up, beaten in a mortar, and pressed. Boil this mass in ½ pint strong vinegar, stirring it from time to time, until it forms a thick liquid compound. Spread this composition thickly over the entire surface of the scorched part, and let it remain on 24 hours. If the scorching was light, this will prove sufficient, with the assistance of two subsequent washings, to take out the stain. If, however, the scorching was strong, a second coating of the composition should be put on after removing the first; and this should also remain on for 24 hours. If, after the linen has been washed twice or thrice, the stain has not wholly dissappeared, the composition may be used again, in proportion to the intensity of the discoloration remaining, when a complete cure will seldom fail to be effected. It has scarcely ever happened that a third application was found necessary. The remainder of the composition should be kept for use in a gallipot tied over with bladder.

505. To Remove the Stain of Perspiration. For removing the stain of perspiration a strong solution of soda is first to be applied, with a subsequent rinsing with water.

506. To Bleach Yellow Linen. Linen that has acquired a yellow or bad color by careless washing, may be restored to its former whiteness by working it well in water containing a clear solution of chloride of lime, rinsing it well in clean water, both before and after using the bleaching liquor. Never attempt to bleach unwashed linen, and avoid using the liquor too strong, as in that case the linen will be rendered rotten.

507. To Bleach Yellow Flannel. Flannel which has become yellow with use may be whitened by putting it for some time in a solution of hard soap, to which strong ammonia has been added. The proportions are 1½ pounds hard curd soap, 50 pounds of salt water and ⅔ pound strong ammonia. The same object may be attained in a shorter time by placing the garments for a quarter of an hour in a weak solution of bisulphite of soda to which a little hydrochloric acid has been added.

508. How to Whiten Flannel and Woolen Hose. Wet the flannel yarn or hose (whatever you wish to whiten) in weak suds; wring out. Then hang on sticks or cords across a barrel with 2 table-spoonfuls of pulverized brimstone or sulphur burning under it; cover the barrel tightly. If they are not white enough, repeat the process; hang in the open air a day, then wash and rinse in bluing water. Be careful not to have the sulphur blaze and scorch the garments.

509. To Bleach Brown Sheeting. Having soaked the cloth 12 hours in strong soap-suds, take ½ pound chloride of lime for every 12 yards of sheeting, and dissolve it in enough boiling water to cover the cloth when dipped into it. As soon as the lime is dissolved, strain the solution through a flannel or other coarse cloth, then put the brown sheeting in the strained lime-water, stirring constantly, and after it has remained thus in this liquor for about half an hour, take out the cloth and rinse it well in pure water, so as to be sure to remove all the lime-water; and then boil it up in strong soap-suds, and hang out to dry, and the work of weeks will have been accomplished in a day or two.

510. Bleaching by Oil of Turpentine. A German authority recommends the use of oil of turpentine in bleaching white goods. Dissolve 1 part oil of turpentine in 3 parts strong alcohol, place a table-spoonful of the mixture in the water used for the last rinsing. The clothes are to be immersed in this, well wrung out, and placed in the open air to dry. The bleaching action of the oil consists in its changing oxygen into ozone when exposed to the light, and in this process the turpentine disappears, leaving no trace behind.

511. To Clean Straw Bonnets. First brush them with soap and water; then with a solution of oxalic acid.

512. To Clean Door-Plates. To clean silver door-plates, use a weak solution of ammonia in water, applied with a wet rag. This wash is equally useful for silver plate and jewelry.

513. To Clean Plated-Ware. Make a paste with whiting and alcohol, apply it to the plated articles, and after it is dry, rub it off with a brush (if rough), or a soft rag, if smooth.

514. To Remove Rust Spots from Marble. Rust spots can be made to disappear by treatment with a weak solution composed of 1 part nitric acid and 25 of water, and afterward rinsing with water and ammonia.

515. To Remove Ink Spots from Marble. Ink spots may be removed by first washing with pure water, and then with a weak solution of oxalic acid. Subsequent polishing, however, will be necessary, as the lustre of the stone may become dimmed. This can be best secured by very finely powdered soft white marble, applied with a linen cloth first dipped in water and then into the powder. If the place be subsequently rubbed with a dry cloth the lustre will be restored.

516. To Remove Copper Spots from Marble. Copper spots may be removed by diluted sulphuric acid and ammonia, and subsequently with water and ammonia.

517. To Remove Match Stains from Marble. Spots from sulphur and phosphorus, caused by lucifer-matches, can be extracted from marble by sulphide of carbon.

The Art of Soap-Making.

Soap is a chemical combination of a fatty substance with caustic lye, the base of which is either potash or soda; the former producing soft, and the latter, hard soaps.

519. To Make Soap-makers' Lye. To 1 part of quicklime, slacked by sprinkling on it sufficient water to crumble it, add a solution of 3 parts soda in 5 parts water. For soft-soap lye, an equal quantity of potash is substituted for the soda. Stir the mixture and allow it to settle; the clear liquid is then poured off, and constitutes the *first lye*, and is of a strength of 25° to 30° Baumé; the *second*, *third* and *fourth* lye is each obtained by adding successively 5 parts water, stirring thoroughly, allowing it to settle, and pouring off the clear liquid; producing respectively a lye of from 12° to 18°, 8° to 10°, and 2° to 5° Baumé.

520. To Make Soap. Having thus prepared the lye, the first, second and third lyes being sufficient for general purposes, take 20 pounds of pure grease, and melt it slowly in an iron vessel; keep it at a moderate heat, and stir in, a little at a time, 10 pounds *third lye*; after stirring for about an hour, let the mixture get up to a boiling heat, and then stir in, by degrees, 10 pounds *second lye*; this will complete the first stage of the process, which is termed *saponification*. The next step, called cutting up the pan, is to add, by degrees, a mixture of soda and lye with from 2 to 3 pounds common salt; this separates the excess of water from the curd, leaving a soapy paste; boil and stir for some time, then let it settle, and draw off the water. The third operation, clear boiling, has now to be performed; stir into the paste, by degrees, 5 pounds *first lye*; and, when perfectly mixed and smooth, boil the whole for two hours; should the soap, during the intervals, become too liquid, which may happen when too weak a lye has been used, some salt, or a weak lye containing salt, must be added. The boiling is terminated when large, regular, dry scales appear on the surface; when this is the case let it settle, and draw off the fluid which remains. Put the soap into frames lined with cotton cloth which has been well powdered with a mixture of lime and starch, and as soon as the soap has become firm, lay it out to dry.

521. Hard and Soft Soap. Soaps are thus of two kinds, hard and soft, this condition being influenced both by the fat and alkali employed. The firmer and harder the fat, the solider will be the resulting soap. With the same alkali, therefore, tallow will make a harder soap than palm or olive oil, and stearic acid than oleic acid. But the consistence of soaps depends far more upon the alkali employed. Potash is very deliquescent, that is, has a strong attraction for water, so that when exposed it will absorb it from the air and run down into a fluid or semi-fluid state. The potash retains this water in the condition of soap, so that potash soaps are always liquid and soft. The hard soaps, therefore, all contain soda, those with tallow or stearic acid being the hardest. Potash soaps will not dry, but retain their soft, jelly-like condition, while some kinds of soda soap become so hard by drying that at last they can be pulverized. The admixture of a very small quantity of sulphate of soda hardens soap and also checks waste from too rapid solubility in hot water. When soda and potash alkalies are used in combination, a proportion of from 10 to 20 per cent. of the latter is employed, according to the degree of hardness the soap is desired to possess.

522. Common Yellow Soap. Common yellow hard soap consists of soda, with oil or fat and resin. Resin is a feeble acid, capable of combining with alkali, but neutralizing it less completely than oil, so that the compound or soap formed is too powerfully alkaline. But when resin is worked with an equal or larger proportion of oil, it makes an excellent soap for many purposes.

523. Beef Tallow. This fat, on account of its abundant supply, is the most used by soap and candle makers. It is not as white as many other animal fats, and the best quality, the North American, contains about 70 per cent. of stearine. It does not melt below 111° Fahr., but may afterwards be cooled down to 102° without solidifying, and when cold, is firm, and even brittle.

524. Mutton Suet. This is generally firm, white, and very rich in stearine; this latter quality gives it a tendency to produce a soap of too hard and brittle a nature for general use, which is obviated by mixing about one-fifth or one-sixth part of lard, or some other more oleaginous fat; thus modified it is specially adapted for stock for toilet soaps.

525. Lard. The best quality of lard melts at 81° Fahr., and contains about 60 per cent. of oily fat, known as lard oil, and about 30 per cent. solid stearine. It makes a pure, white soap, and is frequently combined with tallow or other saponaceous fat.

526. Bone Fat, obtained by boiling fresh bones, split open lengthways, is very well adapted for making soaps, but generally undergoes a process of purification before being thus employed. (*See No.* 534.)

527. Cocoanut Oil possesses two prominent qualities which specially recommend it as an ingredient in soap-making. It imparts a great degree of firmness to the soap, probably owing to the solid form of the fatty acids found in it. It will also unite permanently with soda lyes in any proportion; and, in combination with other fat substances, imparts whiteness and emollient properties to them; it also froths as well in cold as in hot water, which is not the case with tallow soaps worked with soda.

528. Palm Oil. This substance is used in the manufacture of soap. Its genuine quality is easily tested by its solubility in acetic ether, the imitations sometimes sold under the same name being insoluble in it. It is used in its natural state, but its distinctive qualities and white color are greatly increased by bleaching. (*See No.* 537.)

529. To Clarify Fat Used in Making Fine or Toilet Soaps. Heat the fat in a clean iron or copper kettle, applying just heat enough to melt it thoroughly; then filter it through fine linen or muslin.

530. To Deodorize Fat for Making Perfumed Soap. Boil for 10 minutes 100 pounds of the fat with about 35 pounds water containing 6 ounces common salt and 3 ounces powdered alum; strain the water off, and let the fat rest for some hours before using.

531. To Prevent Fatty Substances from Turning Rancid. Boil for about 10 minutes with the salt and alum solution, as in last receipt; strain the water off, and then gently simmer the clarified fat with 4 ounces benzoin and 1 gallon rose water; skim off and let it cool. Fat thus treated will keep for years.

532. To Grain or Granulate Tallow. Melt the tallow and stir it with twice its quantity of water at a blood heat until it is cold; strain the fat from the water, and dry by exposing it to a current of dry air. Tallow in this granulated form combines more readily with lye for soap-making purposes. (*See No.* 535.)

533. To Purify Tallow and Other Fats. Tallow and other fats are commonly purified by melting them along with water, passing the mixed fluids through a sieve, and letting the whole cool slowly, when a cake of cleansed fat is obtained. Another plan is to keep the tallow melted for some time, along with about 2 per cent. of oil of vitriol largely diluted with water, employing constant agitation, and allowing the whole to cool slowly; then to re-melt the cake with a large quantity of hot water, and to wash it well. Another method is to blow steam for some time through the melted fat. By either this or the preceding process a white hard tallow may be obtained. Some persons add a little nitre to the melted fat, and afterwards a little dilute nitric or sulphuric acid, or a solution of bisulphate of potash. Others boil the fat along with water and a little dilute nitric or chromic acid, and afterwards wash it well with water.

534. To Purify Bone Fat. Melt the fat with a small quantity of saltpetre (nitrate of potassa); then add sufficient sulphuric acid to decompose the saltpetre. The mass, after the scum is removed, becomes a light yellow color, and is completely deprived of all offensive smell and animal impurities.

535. To Keep Tallow from Turning Rancid. Cut 50 pounds tallow into slices, and boil it in about 2½ gallons water containing 2 ounces alum and 4 ounces salt; strain the fat from the liquid, and wash it in clean water; put into a clean barrel twice as much water at a blood heat as there is grease, and dissolve in the water about 1 part of clean soap to 10 parts of the grease; next warm the grease to a blood heat and pour it into the barrel of water, stirring it together until cold; let it rest until the fat has risen to the surface, when the water must be drawn away through a hole in the bottom of the barrel, hitherto tightly corked. The fat in a granulated state must be thoroughly dried by exposure to a current of dry air; and, when perfectly dry, packed in barrels or other vessels. The *graining* of the fat at the same time greatly facilitates its combination with lye for the purposes of soap-making.

536. To Preserve Grease. Boil all the scraps, rinds, and bones, in a weak lye, and the purer grease in clear water. Let the mixture cool, take off the cake of grease, and strain it. It is well to do this occasionally, as you save it; for when kept a long time impure grease becomes offensive. You must be careful to dry off all the water before laying it away in the grease tub, if you wish it to keep sweet. The best plan to collect dripping is to put it while warm into water nearly cold. Any impurities it may contain will sink to the bottom.

537. To Bleach Palm Oil. Dissolve ½ pound powdered red chromate of potassa in about a quart hot water. 100 pounds palm oil are heated in a wooden tank, by steam, to a temperature of 120° Fahr. The steam is then turned off and a portion of the chrome solution is stirred in, followed by a proportional quantity of 1 pound strong muriatic acid. After the whole of the solution and of the acid has been thoroughly mixed with the palm oil, stir in ½ pound sulphuric acid. The oil becomes black, then dark green, and finally light green, with a thick froth on the surface. If, when the mixture has settled, the oil is not sufficiently bleached, the operation has to be repeated, using less proportion of chrome and acids. When the bleaching is complete, the oil is allowed to stand for an hour to clear; it is then run into a wooden tank with some water, and heated again, to wash out any salts that may remain in it, and after a time drawn off ready for use. Palm oil is usually combined with from 3 to 5 times its weight of tallow to make soap, and is serviceable in resin soap to brighten its color and disguise the resin.

538. Filled Soap. Hard soaps are usually made according to the process before described (*see No.* 520), the excess of water being separated from the paste by the use of salt: this class of soap is termed *grained soap*. But there are some kinds—cocoanut oil and soda soap, for instance—that are so hard in their nature that the operation of salting, or *graining*, is needless, the water remaining incorporated in the paste; soaps of this class are called *filled soaps*.

539. To Make Tallow Soap. The French Method. Melt in a boiler, by a moderate heat, 500 pounds tallow; stir in, by degrees, 35 to 40 gallons caustic soda lye of 10° to 12° Baumé, and let it boil gently for several hours; then add, gradually, 18 to 20 gallons caustic soda lye of 15° to 18° Baumé, and mix until the whole becomes a homogeneous mass of a grayish color; keep the mixture boiling gently for some hours, adding to it every hour 3 to 4 gallons caustic soda lye of 20° Baumé. This will occupy 10 or 12 hours. The salting process then follows, and is conducted as described in No. 520. After the separation or graining is finished the paste is allowed to stand for a few hours, and the lye is drawn off through a faucet inserted for the purpose in the side of the boiler, near the bottom. The mass is again boiled for some hours, adding every hour 2½ gallons soda lye of 25° Baumé, until the hard scales rise to the surface. (*See No.* 520.) The fire should then be extinguished, and after an hour the under-lye is to be drawn off. Then boil again for 1½ to 2 hours with about 25 gallons soda lye of 4° Baumé, stirring from time to time. The fire should then be removed, and the pan covered up; the soap will rise to the top of the lye, and may be poured into the frames, care being taken that no lye gets mixed with the soap. This should yield about 850 pounds of soap.

540. Tallow Resin Soap. About 15 per cent. of resin can be mixed with tallow without injuring the color and firmness of the soap. A larger proportion deteriorates the quality and produces an inferior soap. Some soap-makers melt the resin and tallow together before saponifying; but it is better to make a soap of each in separate boilers, and then mix and boil them together thoroughly for half an hour, and strain through a sieve before filling the frames.

541. To Make Resin Soap. Boil 12 gallons caustic soda lye of 30° Baumé in a kettle, and add 100 pounds well pulverized resin, 10 or 15 pounds at a time, stirring constantly and thoroughly, the heat being kept up to or nearly at boiling point. Saponification will be effected in about 2 hours. The lightest resin is the best for soap.

542. Cocoanut Oil Soap. Put 100 pounds cocoanut oil and 100 pounds caustic soda lye of 27° Baumé into a soap kettle; boil and mix thoroughly for 1 or 2 hours, until the paste gradually thickens; then diminish the heat, but continue stirring till the cooling paste assumes a white, half-solid mass; then transfer quickly to the frames. A mixture of equal parts of cocoanut oil and tallow will make a very fine *filled* soap. (*See No.* 538.) Cocoanut oil mixed with almost any fats, if they are not in too large proportions, will produce filled soaps.

543. Palm Oil Soap. Palm oil is seldom used alone as a saponaceous fat, but is employed in conjunction with other fats, and with resin; this latter being usually saponified separately and mixed afterwards. (*See No.* 540.) The directions for making tallow soap apply equally well to palm oil. The following are among the best mixtures and proportions of palm oil for soaps:

30 pounds palm oil, 20 pounds tallow, and 2 pounds resin.

30 pounds palm oil, 50 pounds tallow, and 20 pounds resin.

90 pounds palm oil and 10 pounds cocoanut oil.

15 pounds palm oil, 55 pounds lard, 5 pounds cocoanut oil, and 5 pounds clarified resin.

544. To Make Soap from Grained Tallow. Mix 6 pounds caustic soda and 2 pounds caustic potash with 17 to 20 gallons hot water; put a portion of this lye into a clean barrel; stir in by degrees 25 pounds grained tallow; add the rest of the lye and stir it briskly for at least an hour; then let it rest, and before it is cold pour it into a frame or box, and finish according to No. 520.

545. Dawson's Patent Composite Soap. Strong potash lye, 75 pounds; tallow, 75 pounds; cocoanut oil, 25 pounds. Boil until the compound is saponified in the usual manner.

To make 30 pounds of the new composition, take 2 gallons boiling soft water in a kettle, add ½ pound sal soda, 2 ounces borax, 2 table-spoonfuls spirits of turpentine, and 1 tea-spoonful linseed oil. Stir this mixture until the borax and soda are dissolved; then add 15 pounds of the above soap made from lye, tallow, and cocoanut oil; and continue the boiling with stirring for 15 minutes, until the whole is incorporated and dissolved. Now add 2 ounces spirits of hartshorn, and stir. It may be scented with any essential oil, or odor, and colored, if desired; then run off and molded into cakes fit for toilet use. It is a good soap for chapped hands, and is free from any disagreeable odor.

546. Chemical Soap. Powdered fuller's earth, 1 ounce; just moisten with spirits of turpentine; add salt of tartar, 1 ounce; best potash, 1 ounce; work the whole into a paste with a little soap. It is excellent for removing grease spots.

547. To Make Hard White Tallow Soap. Dissolve 2 pounds sal soda in 1 gallon boiling soft water; mix into it 2 pounds fresh slacked lime, stirring occasionally for a few hours; then let it settle, pour off the clear liquid, and boil 2 pounds tallow in it until all the tallow is dissolved. Cool it in a flat box, and cut it into bars or cakes. It can be scented by stirring in the desired perfume when cool.

548. To Make Home-made Caustic Soda. Dissolve 6 pounds common washing soda in 4 gallons warm water; slack 6 pounds clean fresh quicklime in a tub, using only as much water as is needed to crumble it perfectly; add the slacked lime to the solution of soda; stir the two together, adding 4 gallons boiling water; stir thoroughly and let it settle; then pour off the clear lye for use.

549. To Make Domestic Soap. Put the caustic soda lye, prepared in the manner and quantity given in the last receipt, into a clean iron kettle, and add, during continual stirring, 12 pounds clarified grease, dusting in, a little at a time, 4 ounces finely powdered borax; let it boil gently for 10 or 15 minutes, until it thickens and becomes ropy; then have in readiness a tight box, lined with a piece of muslin large enough to hang well over the sides, to allow of the contents being afterward conveniently lifted out; pour the mixture from the kettle into the box, and let it stand for a few days to harden; when sufficiently firm, turn it out onto a table, and cut it into bars with a thin wire. Soap thus made, and left to harden in a dry room, will be fit for use in a month.

550. To Make Home-made Caustic Lye from Ashes. Provide a box whose sides terminate in a point, and having an orifice at the lower end (*see illustration*); this should be mounted high enough to allow of a vessel being placed underneath it, to receive the liquid that runs out of the bottom. The box is then well lined with straw (*see No.* 607), upon which fresh wood ashes are placed, adding to the ashes about one twen-

tieth the quantity of fresh slacked lime (*see No.* 519); then pour hot water upon it, and the lye will filter through into the vessel below. For the purposes of soap-making, this lye must be concentrated by boiling until a sound potato will not sink below the surface.

551. To Make Home-made Soap. Fill an iron kettle two-thirds full of the concentrated lye prepared according to the last receipt; add to it melted fat, a ladleful at a time, stirring constantly until the mass becomes creamy; next add small quantities of salt at a time, stirring without intermission until a perfect ring can be made on the surface with a stick; then let the fire go out and the soap will rise to the surface and harden as it cools; the lye can be drawn from under it by tilting the kettle, or the soap may be lifted off and laid out to dry until hard enough to cut it into bars. (*See No.* 549.)

552. Ox-gall Soap. Gall soap, for the washing of fine silken cloths and ribbons, is prepared in the following manner: In a vessel of copper 1 pound cocoanut oil is heated to 60° Fahr., and ½ pound caustic soda is added, with constant stirring. In another vessel ½ pound white Venetian turpentine is heated, and when quite hot, stirred into the copper kettle. This kettle is then covered and left for 4 hours, being gently heated, after which the fire is increased until the contents are perfectly clear; then 1 pound ox-gall is added. After this, sufficient perfectly dry Castile soap is stirred into the mixture to cause the whole to yield but little under the pressure of the finger; for which purpose, from 1 to 2 pounds of soap are required for the above quantity. After cooling, the soap is cut into pieces. It is excellent, and will not injure the finest colors.

Toilet Soaps.

To this class belong the finer kinds of scented soaps, which have emollient properties. They are rarely made direct by the perfumer, the body or basis being a well-selected white soap, subsequently cleaned and purified. For the choicest grades, the body should be made of a mixture of olive and sweet-almond oil, as the fat stock. Lard and beef tallow make the next best stock; and for palm soap a small quantity of bleached palm oil is to be added to them. Cocoa oil and pale yellow resin saponaceous matters also enter into the composition of certain toilet soaps. These body soaps may be obtained as wanted from any well-conducted soap factory. To be adapted to the purposes of perfumery they must be perfectly neutral, firm, free from unpleasant odor and all tendency to *crust* in cold, or *sweat* in damp weather. They should, moreover, give a rich lather without wasting too rapidly in the water. Soaps, generally, in their original condition, are usually deficient in many of those points; and must, for the purposes of perfumery, undergo a refining process, which is as follows:

554. To Refine Soap for Making Toilet Soap. The soap, as purchased in bars or blocks, being piled upon the shelf of the rasping machine, is next placed in the hopper, and as the wheel revolves, knives come against the soap and cut it into meal, which falls into the reception box beneath. It is now in a state fit to be melted readily, for which purpose it is transferred to a steam bath, and mixed with rose and orange-flower waters, each half a gallon, to every hundred pounds of soap. The steam being let on, and the containing kettle covered, its contents become gradually fluid, and in this state must be stirred with a *crutch*—which is a long stick having the form of an inverted T—until the paste becomes uniformly consistent and smooth throughout. It is then allowed to cool, again melted, but without fragrant water, and crutched as before. When the contents of the vessel comprise several kinds of soap, great care must be observed not to put in all at once, but to add and melt each successively, and to crutch constantly, so as to effect an intimate mixture. When the paste begins to cool, coloring matter as may be desired is then added, and subsequently the perfume, which is reserved to the last, to avoid any unnecessary loss by evaporation from the hot paste.

555. To Perfume, Cut and Stamp Toilet Soap. When extracts or bouquets are used, they must be added to the compound in meal, and incorporated with the mass by kneading it with the hands; for the application of heat would impair the delicacy of the odor, as well as occasion loss by its evaporation. In large establishments this is done by passing the meal repeatedly between marble rollers.

The soap is now ready to be put into the cooling frames, which is a rectangular well, made of a series of wooden frames, resting successively one upon the other. In a day or two it is sufficiently hard to be cut into tablets of the size of the sections of each frame; they are set up edgewise, and left for several days to dry, and are then barred by means of a wire. The sections or *lifts* of the frames regulate the width of the bars, and the gauges adjust their breadth—these latter being made so as to cut bars or squares of four, six, eight or any required number to the pound of soap. The bars are further subdivided into tablets, and subjected to pressure for the purpose of imparting solidity, and ornamenting the exterior with some appropriate device, or impressing upon it the maker's name; the shape of the tablet being determined by the form of the mould or die-box in which it is pressed. The press is of ordinary construction, with spiral springs to throw out the soap tablet from the die-box as soon as it is pressed. In some factories the pressure is more effectually accomplished by means of a steam hammer, which is made to give three blows, directly vertical, to each tablet of soap. Savonettes or soap-balls are shaped by rotating blocks of soap upon a soap scoop made of brass, with sharp edges.

556. To Marble Soap. The mottled or marble appearance is usually given to soap, on the large scale, by watering the nearly finished soap with a strong lye of crude soda (preferably one rich in sulphurets), by means of a watering-pot furnished with a rose-spout. In Castile soap it is given with a solution of sulphate of iron, used in the same way. On the small scale, with toilet soaps, the mottle is either given in the way noticed under "*Mottled Soap Balls*" (*see No.* 576), or, in a like manner, by combining some of the soap, colored at the time of scenting it, with the remaining uncolored portion.

557. Almond Soap. This is a very white soap, which, when genuine, is made by the cold process (*see Nos.* 582 *and* 583), and from pure oil of sweet almonds. The kind, however, generally met with, is made as follows: White curd soap, 100 pounds; cocoanut oil, 15 pounds; purified as before directed (*see No.* 554), and perfumed with a mixture of attar of bitter almonds, 1½ pounds; and attars of cloves and caraway, each 8 ounces.

558. White Windsor Soap. The genuine old white Windsor is made from a body of which a mixture of lard and olive oil is the fat stock; and attars of caraway, lavender, and rosemary, constitute the perfume.

The modern Windsor soap is made from fine white curd soap, 115 pounds; cocoanut-oil soap, 20 pounds; perfumed with a mixture of attar of caraway, 1½ pounds; attars of thyme and rosemary, each 8 ounces; and attars of cassia and cloves, each 4 ounces.

559. Brown Windsor Soap. Curd soap, 100 pounds; cocoanut oil soap, and pale yellow resin soap, each 25 pounds; color with caramel (*see No.* 694), 8 ounces; and perfume with a mixture of attars of caraway, cloves, thyme, cassia, petit-grain, and lavender, each 8 ounces. Morfit's oleic soap, of first grade, is peculiarly adapted as a body for brown Windsor soap, as it gives a rich lather, and is very smooth and highly emollient. Moreover, it contains its normal moisture for a great length of time.

560. Honey Soap. White curd soap, 40 pounds; melted and crutched with white honey, 10 pounds; storax, 2 pounds; and powdered benzoin, 1 pound.

561. Imitation Honey Soap. An imitation honey soap is made by melting together pale yellow soap, 100 pounds; soft soap, 14 pounds; and perfuming with attar of citronella, 1½ pounds.

562. Frangipani Soap. Curd soap, colored brown with caramel, 7 pounds; perfumed with a mixture of attars of neroli and vitivert, each 4 ounces; attar of rose, 2 drachms; attar of santal, 1½ ounces; and civet, 2 drachms. The latter is to be previously triturated with the attars.

563. Rose Soap. This is made from a mixture of olive oil soap, 60 pounds; and curd soap, 40 pounds; colored with 1 pound of finely bolted vermilion. The perfume consisting of attar of rose, 6 ounces; attars of santal and geranium, each 1 ounce; and tincture of musk, 8 ounces; must be added to the cold soap in meal, and incorporated by kneading. The oil soap may be replaced by curd soap, but the quality of the rose soap will not then be so fine.

564. Savon au Bouquet. White soap, 60 pounds; perfumed in the cold with 8 ounces of extract bouquet; or in warm paste with a mixture of attar of bergamot, 8 ounces; attars of cloves and sassafras, each ½ ounce; attar of thyme, 1 ounce; attar of neroli, 1 ounce. The soap body must be previously colored brown with 1 pound of caramel. The soap scented with the attars is inferior to that perfumed with extract bouquet. The perfume, and with it the title of the soap, can be varied according to the caprice of fashion.

565. Poncine Soap. Curd soap, 50 pounds; cocoanut oil soap, the same quantity, melted to paste and crutched with 10 or 20 pounds of finely bolted pumice-stone powder. The perfume is a mixture of attars of thyme, cassia, caraway, and lavender, each 1 pound.

566. Spermaceti Soap. The genuine spermaceti soap is superior to all others in emollient properties; but it is rarely made from pure stock, owing to the difficulty in saponifying it. As generally vended it consists of white curd soap, 14 pounds; perfumed with a mixture of attar of bergamot, 2½ ounces, and attar of lemon, 8 ounces.

567. Palm Soap. Curd soap, made of a mixture of ½ lard, ¼ bleached palm oil, and the remainder olive oil or spermaceti, constitutes the body of palm soap. Its natural odor is that of the violet, which is sometimes stimulated by the addition of a little attar of portugal, with a less portion of attar of cloves.

568. Floating Soap. All the hard soaps increase bulk by mechanical batting of the paste; the loss of density thus produced gives them the property of floating in water. The batting is best accomplished by means of a churn-twirl, rotating on a pivot in the bottom of the melting pan, and put in motion by a handle.

Expose 5 pounds olive-oil or almond soap, and 1½ pints soft water in a bright copper pan, to a steam or water heat, and assiduously beat and agitate the mixture until it has more than double its volume; then pour it into a cold frame, cool it quickly, and, when hard, cut it into bars or cakes. It may be colored and scented at will. Floats on water, and lathers freely, but will not bear soaking or much wet, as it rapidly softens.

569. Transparent Soap. This amber-looking soap is made by dissolving hard white soap, previously reduced to meal and thoroughly dried, in alcohol. A steam-bath, fitted with a still-head, makes a good containing vessel. The alcohol and soap are taken in about equal proportions; and, as the solution proceeds, any spirit which may distill over must be allowed to condense in a worm, and collected in a receiver. The heat should not exceed 212°. After solution, the whole must be allowed time for settling; after which, the clear fluid is to be drawn off from the sediment into wooden frames; or globular moulds of britannia metal, if it is desired to cast it in ball form. Previous to settling it may be colored as desired—red, with tincture of alkanet; yellow, with tincture of turmeric; orange, with a mixture of the two tinctures; green, with tincture of chlorophyle; blue, with tincture of indigo carmine. Transparent soap is rather translucent when first made, and does not clear until perfectly dry. The perfumes are the same as for the other soaps.

570. Glycerine Soap. Any mild toilet soap (as the basis of bouquet, rose, or Windsor soap) with which about $\frac{1}{17}$ to $\frac{1}{15}$ of its weight of Price's glycerine has been intimately incorporated whilst in the melted state. It is generally tinged of a red or rose color, with a little tincture of archil or of dragon's blood; or orange yellow, with a little annatta. It is variously scented; but oil of bergamot, or rose-geranium (ginger-grass), supported with a little oil of cassia, or cassia supported with essential oil of almonds, appear to be its favorite perfumes.

571. Musk Soap. Best tallow soap, 30 pounds; palm oil soap, 20 pounds; powdered cloves, pale roses and gilliflowers, of each 4½ ounces; essence of bergamot and essence of musk, of each 3½ ounces; Spanish brown, 4 ounces.

572. Orange Flower Soap. Best tallow soap, 30 pounds; palm oil soap, 20 pounds; essence of portugal and essence of ambergris, each 7½ ounces; yellowish green coloring, made of ochre and indigo, 8½ ounces; vermilion, 1½ ounces.

573. Cinnamon Soap. This is usually a mixture of tallow and oil soaps, like that of "savon au bouquet," colored with about ¼ pound yellow ochre, and scented with 1 ounce oil of cinnamon (supported with a little oil of bergamot and sassafras), to each 7 pounds. The following is the form of a celebrated maker of this soap, and is very fine:

6 pounds finest white curd soap; 3½ pounds finest palm oil soap; 1 pound olive oil soap; 1½ ounce oil of cinnamon; ½ ounce oil of bergamot; ½ ounce oil of sassafras; 1 drachm English oil of lavender; and about ½ pound levigated yellow ochre.

Oil of cassia is commonly substituted for the oil of cinnamon; and always so in second and inferior qualities.

574. Glycerine Soap Balls. To any recently made toilet soap, sliced, and melted by a gentle heat, without water (if possible), add Price's glycerine, in the proportion of 1 ounce to the pound; thoroughly incorporate them by vigorous stirring, which should be continued until the mass has cooled considerably, when it should be at once made into balls.

575. Sand Soap Balls. These are prepared by adding to the melted soap about half its weight of fine siliceous sand. Sifted sand is usually employed. Some persons prefer the shelly sea-sand (sifted from the shells and well washed) for the purpose. For the finer qualities, finely-powdered pumice-stone is now usually employed. Used to prevent roughness and thickening of the skin in cold weather; also to clean the hands when dirty. The best yellow soap, with or without the addition of ¼ its weight of white soft soap and a little sweet oil, is the best for these balls.

576. Mottled Soap Balls. Cut the soap (recently prepared, and not too dry) into dice, or small square pieces, roll them in colored powder (*see below*), and then mould them into balls by powerful pressure, observing to mix the colors as little as possible.

The colors usually employed, and which should be in very fine powder, are: *Blue*—indigo, powder-blue, or smalts. *Green*—powder-blue and bright yellow-ochre. *Orange*—yellow deepened with a little red. *Red*—red bole, sesquioxide of iron, or jeweler's rouge. *Yellow*—bright yellow-ochre, or Dutch pink.

By varying the shade of color, which is done by diluting it with a little farina or chalk, and by using soap-dice separately coated with two or more colors, "mottled savonettes" of any color, or mixture of colors, may be produced at will.

577. Mercurial Soap. Take of corrosive sublimate (crushed small), 1 drachm; rectified spirit (to dissolve, say) 1 fluid ounce; white Castile soap (in powder), 4 ounces; beat them to a uniform mass in a wedgwood-ware mortar, adding a few drops of attar of roses, or of a mixture of the oils of cassia and bitter almonds. Nothing metallic must touch it. This is the "sapo hydrargyri bichloridi" of medical writers. The above has been recommended in various skin diseases, including itch; also as "Savon Antisyphilitique," under which name it is often sold.

578. Sulphur Soap; Sulphuretted Soap. Take ½ pound white curd or Castile soap (recent); 1 ounce best flowers of sulphur (levigated); 1 fluid ounce rectified spirit (strongly colored with alkanet); and sufficient attar of roses to strongly scent the mass. Beat the whole together, to a smooth paste, in a marble or wedgwood ware mortar. This is Sir H. Marsh's formula. Recommended in itch, and various other skin diseases. It is particularly serviceable as a common toilet soap, to persons troubled with slight cutaneous eruptions. Its daily use tends to render the skin fair and smooth. The spirit and coloring may be omitted at will; and, as a toilet soap, only half the above quantity of sulphur is amply sufficient.

579. Caution in using Medicated Soaps. Before using mercurial or sulphur soap, finger-rings, ear-rings, and bracelets of gold, &c., should be removed, and not replaced until some short time after the hands have become quite dry; as otherwise they will be tarnished, and even blackened and corroded. The same applies to all other cosmetics containing the same mineral ingredients.

580. Whale-oil Soap to Destroy Insects. Render common lye caustic, by boiling it at full strength on quicklime; then take the lye and boil it with as much whale-oil foot as it will saponify (change to soap), pour off into moulds, and, when cold, it is tolerably hard. Whale-oil foot is the sediment produced in refining whale oil.

581. Carbolic Acid Soap. Take freshly prepared cocoanut-oil soap, 150 parts, and fuse; then add a solution of alcohol, 10 parts; carbolic acid, 6 parts; caustic potassa, 2 parts; oil of lemon, 1 part; and mix with stirring. To be poured into moulds.

Soap by the Cold Process.

Although the commoner kinds of soap are usually made by boiling, they can be made by the cold process if desired; and the fatty substances employed are substantially the same in both methods. The cold or little-pan process is, however, almost exclusively adopted in the manufacture of fancy or toilet soaps, and for these purposes the fat requires to be purified and deodorized, especially where any delicate scent is to be used in perfuming it. (*See Nos.* 533 *and* 530.) The lye employed for saponification without boiling must be much stronger than that used in the boiling process, and should be entirely clear and colorless; a strength of about 36° Baumé is usually necessary.

583. To Make Soap by the Cold Process. Incorporate by degrees 50 pounds concentrated caustic lye of 36° Baumé, into 100 pounds fat at a temperature not higher than 104° Fahr. (*see No.* 523); continue to stir thoroughly with a broad wooden paddle, until a complete ring can be drawn on its surface with the paddle. In making scented soap, the perfuming ingredients must now be stirred in. The paste is then run into frames lined with linen, flaps of which should be left above the edges of each frame, wide enough to admit of their being laid over the surface of the paste, with which the frame must be *entirely* filled. The paste being thus completely confined by the linen, the frames are closed with a wooden cover and left for 12 hours. During this interval the temperature of the paste in the frames rises spontaneously to a much higher degree, producing complete saponification. The soap is afterwards taken out of the frames, cut, and dried. The hardness of the soap will depend on the description of fats and lyes used. (*See No.* 521.)

584. Method of Testing Caustic Alkali. The strength and practical value of commercial caustic soda or potash can only be ascertained by analysis. The methods given below are simple, and will determine, with sufficient accuracy, the percentage of water, caustic alkali, and carbonated alkali contained in a given sample; and hence the quantity of impurity, if any.

585. To Find the Percentage of Water in a Caustic Soda or Potash. Weigh carefully 100 grains of the alkali into a capsule (a flat evaporating dish of suitable size, a watch glass is a small capsule), and dry them by heating over a flame; a cold glass held over the contents of the capsule will show the slightest evaporation of water. When no more moisture can be detected, allow them to cool; then weigh the residue in the capsule, and the difference of the weights before and after drying will be the number of grains of water contained in 100 grains of the alkali; that is, the percentage of water.

586. To Estimate the Percentage of Caustic Alkali in a Caustic Soda or Potash. Powder 100 grains of the alkali to be tested; put it into a flask containing an ounce of 95° alcohol, and shake thoroughly; the alcohol dissolves the caustic alkali perfectly, but will not take up any other ingredients. After standing for a few hours to settle, decant the clear liquid, and evaporate on a porcelain capsule until thoroughly dry; the weight of the dry residue will be the number of grains, *i. e.*, the percentage, of caustic alkali in 100 grains of the soda or potash.

587. To Find the Percentage of Carbonated Alkali in a Caustic Soda or Potash. Dissolve 100 grains of the sample in 4 ounces water in a flask; next weigh out 100 grains finely powdered crystals of oxalic acid; add small portions of this acid at a time to the alkali in the flask, stirring thoroughly with a glass rod, and apply heat; continue to add the acid until the hot mixture tinges litmus paper slightly red; the saturation is then complete, and the acid has neutralized or combined with *all* the alkali, both carbonate and caustic. Weigh the oxalic acid which remains; and, by deducting from 100, we know how much we have used. Now every 7.87 grains oxalic acid that have been used, have neutralized 5 grains soda or 7 grains potash, according as the sample consists of caustic soda or caustic potash; hence we find the total number of grains of *alkali* in the 100 grains under test. By the previous method we can find the percentage of *caustic alkali* in 100 grains of the sample; deducting the grains of this latter from the weight of the whole alkali eliminated by the oxalic acid, the balance or remainder will be the percentage of *carbonated alkali*.

By these three steps we get the percentage of water, the percentage of caustic alkali, and the percentage of carbonated alkali; these added together and deducted from 100 give the percentage of foreign matter or impurity in the matter tested. (*See Alkalimetry.*)

588. To Make Soap-makers' Concentrated Caustic Lye. Boil 85 gallons water in a kettle capable of holding 150 gallons; stir in, a little at a time, 100 pounds powdered soda (or potash, if for potash lye), until it is all dissolved; then mix in gradually, by stirring, 48 pounds freshly slacked lime of a creamy consistency; the boiling must not be allowed to slacken during the whole process, until complete causticity is obtained, which may be ascertained by taking a little in a test glass, and, *when cool*, adding to it a few drops of nitric acid; if this causes effervescence, the causticity is imperfect and the boiling must be continued until a test with nitric acid causes no effervescence. When this is the case, the contents of the kettle should be allowed to cool and settle for about 12 hours. The clear liquor can then be drawn off into a vat lined with lead—a syphon may be used for this purpose with advantage. The lye can be made to any desired strength by evaporation.

589. To Make Concentrated Caustic Soda Lye—Kurten's Method. The lye fit for toilet soap must be either made from the purest German soda at 95 degrees of strength, or (which is better for the purpose) from crystallized soda. English soda of 80 to 83 degrees, such as is generally found in commerce, is not to be used, as it produces a bad article.

When the lye for finer soap is to be made, 100 pounds lime are added to 100 pounds German soda at 95 per cent., whereas 45 pounds lime to 100 pounds crystallized soda is the general proportion.

The soda is dissolved in the boiler with water, or with a weak lye remaining from a former operation at 20 degrees of strength, and afterwards added to the lime slacked to a state like broth. This mixture must boil 2 hours and be left to deposit.

The next day, the lye, which probably may be at 12 degrees (Baumé) must be taken out, and the boiler filled afresh. The lye drawn from the lime and at 8 degrees, is poured in with it to evaporate. By this method a lye is produced at a medium of 9 or 10 degrees, but it must be evaporated till, according to areometer, it shows 34 degrees. After the cooling it will weigh 36 pounds. This evaporation of the lye is to increase its causticity, and to cause all the dirt contained in it to precipitate to the bottom, which can be done in a day if it is sufficiently strong.

The clear lye is then drawn off from the dirty deposit, and put either into vitriol bottles or into an iron vessel well covered. If vitriol bottles are used, they must be filled with water in which some lime has been dissolved, to take away any acid remaining in the bottle, which would, if this precaution be not taken, absorb much of the causticity of the lye; and this must be done several days before using the bottles. The dirt and deposit from the salt remaining at the bottom after the boiling, can be added to the lime in the weak lyes.

We have not made the experiment of using the lye stronger than 11 degrees before evaporation, as we have learned from France that it must not be stronger than 11 degrees. Yet, after mature experience, it appears to us now that a lye can be obtained quite as good by adding more soda and lime to the lye, and thus increasing the strength to 18 or 20 degrees, by which the evaporation is spared. In this case more vessels are wanted, which must not be of wood, but of iron, because the wood will color the lye, which must be especially avoided for fine soap, for the only means of obtaining a perfect soap, free from defect, is to use none except the finest and whitest lye, and oil or grease of the greatest purity.

590. To Test Lye. In testing the strength of lyes with a hydrometer, an exact result could be obtained if the caustic alkali employed by soap-makers and dyers were absolutely pure; but as this is seldom, if ever, the case, the impurities which exist in the lyes under examination, influence the specific weight of the lye, and due allowance must be made for this; thus, an indication by the hydrometer of 20 per cent. does not prove that the lye contains 20 per cent. of pure caustic alkali, but includes the foreign matter. Still, this method of testing will give *com-*

paratice strengths exactly.

591. **White Soap.** Lard, 40 pounds; and caustic soda lye, of 35° Baumé, 20 pounds. Melt the fat by a heat not exceeding 150° Fahr.; add, during constant stirring, 10 pounds of the lye. After one hour's stirring, the heat being continued all the time at a moderate degree, the remaining 10 pounds of lye are to be added. When the paste has become smooth and uniform throughout, it is transferred to a cooling frame, perfumed, and left in a room of moderate temperature for a few days to set and ripen. It is then ready to be cut into tablets and pressed.

592. **Almond Soap.** Genuine almond soap is made from oil of sweet almonds, 50 pounds, and soda lye of 36° Baumé, 25 pounds, the latter being gradually added to the former at a temperature between 125° to 150°, and the whole stirred constantly until the mixture is a smooth paste. It is then transferred to a cooling frame, perfumed with attar of bitter almonds, and then left for several days to set and ripen.

593. **Ordinary Cocoanut Oil Soap.** 100 pounds cocoanut oil—or 90 pounds cocoanut oil and 10 pounds of either tallow or palm oil—saponified by the cold process with 225 pounds caustic soda lye of 21° Baumé, and 75 pounds of salt water of 12° Baumé, will combine to form 400 pounds of cocoanut oil soap.

594. **Cocoanut Oil Soap.** 100 pounds cocoanut oil and 56 pounds caustic soda lye of 36° Baumé, treated according to the cold process, will produce 153 pounds cocoanut oil soap.

595. **Paris Toilet Tablet Soap.** 87 pounds of this soap can be made by the cold process by using the following ingredients: 20 pounds tallow, 30 pounds cocoanut oil, 8 pounds lard, 31 pounds caustic soda lye of 30° Baumé, and 5 pounds caustic potash lye of the same strength.

596. **Paris Toilet Round Soap.** 25 pounds cocoanut oil, 75 pounds lard, 50 to 52 pounds caustic soda lye of 36° Baumé, will produce 150 pounds of the soap.

597. **Shaving Soap.** Either 66 pounds tallow and 34 pounds cocoanut oil—or 33 pounds of tallow, the same quantity of palm oil, and 34 pounds cocoanut oil—treated by the cold process with 120 pounds caustic soda lye of 27° Baumé, will make 214 pounds of shaving soap. An addition of 12 pounds of salt water of 12° Baumé to the palm oil mixture, will add 12 pounds to the yield of soap.

598. **Washing Soap.** A mixture of either 60 pounds tallow—or 30 pounds each of tallow and palm oil—with 40 pounds of cocoanut oil, treated by the cold process with 125 pounds caustic soda lye of 27° Baumé, and 25 pounds salt water of 12° Baumé, will turn out 244 pounds washing soap.

599. **Cheap Washing Soap.** 60 pounds cocoanut oil with 40 pounds of either tallow or palm oil, treated cold with 135 pounds caustic soda lye of 27° Baumé, and 50 pounds salt water of 15° Baumé, will produce 278 pounds washing soap.

Soft Soaps. These differ from the hard soaps in having potash in place of soda as their alkaline base. They are all more or less pasty or gelatinous; and they may be made either by the boiling or cold process. Of the soft soaps used in perfumery, that known as fig soap is the only one that is boiled.

601. **Fig Soap.** The fat stock is chiefly oil—generally olive oil—with the addition of a little tallow to give it the granular appearance called fig.

602. **Shaving Cream.** This is made by melting 20 pounds of lard in a steam bath at a temperature of 212°, and then letting 5 pounds of caustic potassa lye of 36° Baumé run in *very slowly*, during constant stirring with a wooden paddle; when the paste becomes thick, 5 pounds more of lye are added in the same manner. After several hours' stirring the paste becomes firm, and is finished. It is then transferred to a mortar and triturated until the soap becomes perfectly even throughout, and assumes a pearly appearance. Attar of almonds is the perfume for almond cream; and attar of rose for rose cream. They are dissolved in a little alcohol, and added during the trituration. The rose cream is colored at the same time with tincture of alkanet.

603. **Rypophagon Soap.** This is a mixture of equal parts of pale yellow resin soap and fig soft soap, perfumed with attars of anise and citronella.

604. **Essence of Soap or Shaving Cream.** Take ½ pound white soft soap (*see No.* 606), 2 fluid drachms liquor of potassa; 1 pint rectified spirit, and perfume at will; put them into a strong bottle of glass or tin, cork it close, set it in warm water for a short time, and occasionally agitate it briskly until solution be complete. After repose, pour off the clean portion from the dregs (if any) into clean bottles for use, and at once closely cork them. If the solution be not sufficiently transparent, a little rectified spirit should be added to it before decantation. A little spirit (fully proof) may be added if it be desired to render it thinner. If much essential oil be used to perfume it, the transparency of the product will be lessened.

605. **Soft Olive Oil Soap; Medicinal or Toilet Soft Soap** is soap made of olive oil and potash. It is yellowish-white, inodorous, and of the consistence of thick honey. It is the soft soap (sapo mollis) of the British Pharmacopœia.

606. **White Soft Soap** is soap made of lard and potash. Only used in cosmetics and as a toilet soap.

607. **Fine Shaving Cream.** Take of clarified lard, 7 pounds (avoirdupois); potash lye (26 per cent. of caustic potash), 3½ pounds; rectified spirits, 3 ounces; oil of bitter almonds, 2 drachms. Melt the lard in a porcelain vessel, by a salt-water bath; then run in the lye, very slowly, agitating the whole time; when about half the lye is in, the mixture begins to curdle; it will, however, become so firm that it cannot be stirred. It will assume a pearly appearance by triturating in a mortar, and slowly adding the alcohol, holding the oil of almonds in solution. This furnishes a splendid shaving cream.

608. **To Make Good Common Soft Soap.** For a barrel of soap take 12 pounds of potash to 14 pounds of grease. Dissolve the potash over night in 2 pailfuls of hot soft water, in the morning pour it hot over the grease, which must have been previously rendered down and put in the barrel, put more water on the potash that remains undissolved; when hot, add as before, and so on until all the potash is dissolved; fill up the barrel more slowly with cold water, finishing it the next day; stir it very frequently during the day and for several successive days. Allow it to rest for three months in the cellar.

609. **Shaker Method of Making Soft Soap.** Place a shallow iron kettle, to hold from 4 to 6 barrels, just out of the wash-room, under cover of a shed. Extend ½ or ¾ inch pipe for steam to the middle of the bottom, bending it to form of surface, and terminating with open end. Take another pipe to discharge cold water over the top of the kettle. Use the best quality of first sorts of potash, in the proportion of 6 pounds of potash to 7 pounds of grease, for a barrel of 40 gallons. Break up the potash into small lumps, and dissolve it in say 2 pails of hot water to 24 pounds. It dissolves rather slowly when the potash is good. When dissolved, put the solution into the kettle, add the grease quite warm, and stir the mixture together. Allow it to stand over night, if convenient. In the morning, apply a moderate jet of steam until the mixture appears ropy, or rather soapy. Shut off the steam and open the cold water valve, stirring the mixture as the water runs, until the kettle is full, or the required quantity obtained for the materials used.

610. **To Make Good Lye.** Hickory ashes are the best for making common washing soft soap (when it is not desirable to use the potash lye), but those from sound beech, maple, or almost any kind of hard wood, except oak, will answer well. A common barrel, set upon an inclined platform, makes a very good leach, but one made of boards set in a trough in V shape is to be preferred, for the strength of the ashes is better obtained, and it may be taken to pieces when not in use, and laid up. First, in the bottom of the leach put a few sticks; over them spread a piece of carpet or woolen cloth, which is much better than straw; put on a few inches of ashes, and from 4 to 8 quarts lime; fill with ashes, moistened, and tamp down well—tamp the firmest in the centre. It is difficult to obtain the full strength of ashes in a barrel without removing them after a day's leaching, and mixing them up and replacing. The top should be first thrown off, and new ashes added to make up the proper quantity. Use boiling water for second leaching. This lye should be sufficiently strong to float a potato.

611. **To Make Soft Soap.** Take about 4 gallons the above lye, and boil up thoroughly with 12 pounds of clear grease, then add the lye as it is obtained, keeping a slow fire, and stirring often, until you have a barrel of soap. After boiling the grease and 4 gallons of lye together, it may be put in a barrel and the rest of the lye added there, which will form good soap if frequently stirred, but the heating process is the best when weather and time will permit the work to be done.

612. **To Make Soft Soap.** Break up 8 pounds potash into small lumps, and put it into an iron pot with about 3 gallons boiling water; melt in another iron pot 8 pounds clarified fat; put 3 or 4 gallons hot water into a clean barrel, and add to it a ladleful each of the lye and the fat; stir thoroughly, and add the lye and the fat, a single ladleful of each at a time, until the whole is thoroughly mixed; then stir in a ladleful of hot water at a time until the barrel is full, and stir till the mixture becomes a creamy mass; put it away for 3 months in a moderately cool place and it will be ready for use.

613. **To Make Turpentine Soap.** Cut up 3 pounds brown soap and melt it in 7 quarts water, then put it in a stone pot and add 9 table-spoonfuls spirits of turpentine and 6 of alcohol.

614. **To Use Turpentine Soap.** Make very hot suds with some of the soap (*see last receipt*), and let the clothes remain in it half an hour. Then wash them out and rinse as other clothes are done. It is particularly nice for blankets and quilts, as it removes the dirt and requires very little rubbing.

615. **To Make Soft Soap Hard.** Put into a kettle 4 pailfuls of soft soap, and stir in it, by degrees, about 1 quart of common salt.

Boil until all the water is separated from the curd, remove the fire from the kettle, and draw off the water with a syphon (a yard or so of india rubber hose will answer). Then pour the soap into a wooden form in which muslin has been placed. (*See No.* 549.) For this purpose, a wooden box, sufficiently large and tight, may be employed. When the soap is firm, turn it out to dry, cut into bars with a brass wire and let it harden. A little powdered resin will assist the soap to harden, and give it a yellow color. If the soft soap is very thin, more salt must be used.

616. Labor-saving Soap. Take 2 pounds sal soda, 2 pounds yellow bar soap, and 10 quarts water. Cut the soap in thin slices, and boil together 2 hours; strain, and it will be fit for use. Put the clothes in soak the night before you wash, and to every pail of water in which you boil them, add a pound of soap. They will need no rubbing; merely rinse them out, and they will be perfectly clean and white.

617. To Estimate the Quality of Soap. The quality of soap may be properly estimated from the amount of fatty acids which any given specimen contains. The following simple analysis may be performed by any one, and may be relied upon as giving good results. The soap to be examined should be dissolved in water. If distilled water cannot be readily obtained, rain water will answer well enough. When a perfect solution is obtained, add hydrochloric acid. After a little while the fatty acids will be found to be separated from the other constituents of the soap. These should be collected, and their relative weight for any given quantity estimated. The relative weight thus found will be a sufficiently just indication of the quality.

618. To Test Soap. The readiest way to find whether soap will injure the delicate skin of women or children is to test it with the tongue. Good soap, in which the caustic alkali is neutralized by thorough combination with the fat, will not have a sharp taste. The soap used in medicine, and the transparent soaps, are neutral and good. Many toilet soaps, and especially the imitation marbled castile soap, so abundant in the trade, contain too much free alkali. They have not been thoroughly boiled, and are very sharp. It is not advisable to use such soaps upon delicate skins, as they induce redness of appearance, and give the skin a tendency to roughen or chap, especially when exposed to the wind.

619. To Pulverize Hard Soap. Hard bar soap should be scraped or planed into fine shavings, dried in the sun, or by heat, thoroughly, and then pounded or crushed. After this, it should be placed in a bowl or kettle, and a small cannon ball should be used to pulverize it; when thoroughly pulverized it may be sifted through a very fine sieve.

620. To Analyze Soap. Take a small portion of the soap, place it in a suitable vessel (a beaker glass), add ether to it, and next acetic acid in a somewhat smaller quantity. The liquid will separate, after a while, into two distinct layers, the upper of which contains in solution the fatty acids, while the lower layer contains the alkalies and salts, and such substances as might happen to be insoluble in the two fluids just named. By means of a pipette, the fluids are separated from each other. The ethereal solution is poured into a previously weighed beaker glass, and the ether evaporated upon a water bath, and next again weighed with the fatty acids it contains. The aqueous acetic acid is evaporated to dryness, and the quantity of alkali determined according to well-known methods. (*See No.* 586).

621. Analysis of Soda and Potassa Lyes. The following tables will show at a glance all the practical information necessary for analyzing or testing the strength of lyes, either simple or caustic, as well as affording thorough guidance in mixing or adjusting the strength of lye for any specific purpose.

622. Lormé's Tables. The following tables are used to transform stronger lyes into weaker of a definite degree of strength, and are by Mr. Eugène Lormé.

The first column at the left of each table shows the quantity and the degree of the lye to be diluted.

The second indicates the quantity of water to be added to the lye.

The third gives the amount of the lye obtained by the admixture of both liquids.

The fourth exhibits the degrees of Baumé's areometer of the lye.

623. Table showing the different Areometric Degrees resulting from a mixture of 10 gallons of soda lye, of 36 degrees Baumé, with quantities of water varying from 10 to 90 gallons.

Number of gallons of Lye of 36 degrees.	Number of gallons of Water.	Number of gallons of obtained Lye.	Degrees of Baumé of the mixture.
10	10	20	23°
10	20	30	17
10	30	40	14
10	40	50	12
10	50	60	10
10	60	70	9
10	70	80	8
10	80	90	7½
10	90	100	6¾

10 gallons of lye, of 36 degrees Baumé, weigh 112½ lbs.

624. Table showing the different Areometric Degrees resulting from a mixture of 10 pounds of soda lye, of 36 degrees Baumé, with quantities of water varying from 10 to 90 pounds.

Number of pounds of Lye of 36 degrees.	Number of pounds of Water to be employed.	Number of pounds of Lye obtained.	Degrees of Baumé of the mixture.
10	10	20	21°
10	20	30	14½
10	30	40	11¼
10	40	50	10
10	50	60	9
10	60	70	8
10	70	80	6¼
10	80	90	5¼
10	90	100	5 nearly

8.8 gallons of lye, of 30 degrees Baumé, weigh 100 pounds.

625. Table showing the different Areometric Degrees resulting from a mixture of 10 gallons of soda lye, of 30 degrees Baumé, with quantities of water varying from 10 to 90 gallons.

Number of gallons of Lye of 30 degrees.	Number of gallons of Water to be employed.	Number of gallons of Lye obtained.	Degrees of Baumé of the mixture.
10	10	20	19°
10	20	30	nearly 14
10	30	40	11
10	40	50	9
10	50	60	8
10	60	70	7
10	70	80	6
10	80	90	5
10	90	100	4½

10 gallons of soda lye, of 30 degrees, weigh 104 pounds; 75 gallons of this lye and 25 gallons of water give 100 gallons of lye of 25 degrees Baumé. There are 23½ pounds of caustic soda wanted for making 10 gallons of lye of 30 degrees Baumé.

626. Table showing the different Areometric Degrees resulting from a mixture of 10 pounds of soda lye, of 30 degrees Baumé, with quantities of water varying from 10 to 90 pounds.

Number of pounds of Lye of 30 degrees.	Number of pounds of Water to be employed.	Number of pounds of Lye obtained.	Degrees of Baumé of the mixture.
10	10	20	17°
10	20	30	12
10	30	40	9¼
10	40	50	7¼
10	50	60	6¼
10	60	70	5¼
10	70	80	5 or 5¼
10	80	90	4¼
10	90	100	4

9.6 gallons of lye, of 30 degrees Baumé, weigh 100 pounds.

627. Gerlach's Table, showing the percentage of Carbonate of Soda contained in its Solutions.

Per cent.	Specific Weight.	Per cent.	Specific Weight.
1	1.00914	27	1.26787
2	1.01829	28	1.27893
3	1.02743	29	1.28999
4	1.03658	30	1.30105
5	1.04572	31	1.31261
6	1.05513	32	1.32417
7	1.06454	33	1.33573
8	1.07396	34	1.34729
9	1.08337	35	1.35885
10	1.09278	36	1.37082
11	1.10258	37	1.38279
12	1.11238	38	1.39476
13	1.12219	39	1.40673
14	1.13199	40	1.41870
15	1.14179	41	1.43104
16	1.15200	42	1.44338
17	1.16222	43	1.45573
18	1.17243	44	1.46807
19	1.18265	45	1.48041
20	1.19286	46	1.49314
21	1.20344	47	1.50588
22	1.21402	48	1.51861
23	1.22459	49	1.53135
24	1.23517	50	1.54408
25	1.24575	51	1.55728
26	1.25681	52	1.57048

628. Schiff's Table, showing the percentage of Crystallized and Anhydrous Soda in Solutions of Carbonate of Soda.

Specific Weight.	Per cent. of Crystallized Soda.	Per cent. of Anhydrous Soda.
1.0038	1	0.370
1.0076	2	0.741
1.0114	3	1.112
1.0153	4	1.482
1.0192	5	1.853
1.0231	6	2.223
1.0270	7	2.594
1.0309	8	2.965

1.0348	9	3.335
1.0388	10	3.706
1.0428	11	4.076
1.0468	12	4.447
1.0508	13	4.817
1.0548	14	5.188
1.0588	15	5.558
1.0628	16	5.929
1.0668	17	6.299
1.0708	18	6.670
1.0748	19	7.041
1.0789	20	7.412
1.0830	21	7.782
1.0871	22	8.153
1.0912	23	8.523
1.0953	24	8.894
1.0994	25	9.264
1.1035	26	9.635
1.1076	27	10.005
1.1117	28	10.376
1.1158	29	10.746
1.1200	30	11.118
1.1242	31	11.488
1.1284	32	11.859
1.1326	33	12.230
1.1368	34	12.600

Schiff's Table (Continued).

Specific Weight.	Per cent. of Crystallized Soda.	Per cent. of Anhydrous Soda.
1.1410	35	12.971
1.1452	36	13.341
1.1494	37	13.712
1.1536	38	14.082
1.1578	39	14.453
1.1620	40	14.824
1.1662	41	15.195
1.1704	42	15.565
1.1746	43	15.936
1.1788	44	16.307
1.1830	45	16.677
1.1873	46	17.048
1.1916	47	17.418
1.1959	48	17.789
1.2002	49	18.159
1.2045	50	18.530

629. Table showing the percentage of Anhydrous Potassa in Caustic Potassa Lye.

Specific Gravity.	Potassa in 100.	Specific Gravity.	Potassa in 100.
1.3300	28.290	1.1437	14.145
1.3131	27.158	1.1308	13.013
1.2966	26.027	1.1182	11.882
1.2805	24.895	1.1059	10.75
1.2648	23.764	1.0938	9.619
1.2493	22.632	1.0819	8.487
1.2342	21.500	1.0703	7.355
1.2233	20.935	1.0589	6.224
1.2122	19.803	1.0478	5.002
1.1979	18.671	1.0369	3.951
1.1839	17.540	1.0260	2.829
1.1702	16.408	1.0153	1.697
1.1568	15.277	1.0050	0.5658

630. Table showing the percentage of Caustic Soda in Soda Lye.

Specific Gravity.	Per cent.	Specific Gravity.	Per cent.
1.4285	30.220	1.2392	15.110
1.4193	29.616	1.228	14.505
1.4101	29.011	1.2178	13.901
1.4011	28.407	1.2058	13.297
1.3923	27.802	1.1948	12.692
1.3836	27.200	1.1841	12.088
1.3751	26.594	1.1734	11.484
1.3668	25.989	1.1630	10.879
1.3585	25.385	1.1528	10.275
1.3505	24.780	1.1428	9.670
1.3426	24.176	1.1330	9.066
1.3349	23.572	1.1233	8.462
1.3273	22.967	1.1137	7.857
1.3198	22.363	1.1042	7.253
1.3143	21.894	1.0948	6.648
1.3125	21.894	1.0855	6.694
1.3053	21.154	1.0764	5.540
1.2982	20.550	1.0675	4.835
1.2912	19.945	1.0587	4.231
1.2843	19.341	1.0500	3.626
1.2775	18.730	1.0414	3.022
1.2708	18.132	1.0330	2.418
1.2642	17.528	1.0246	1.813
1.2578	16.923	1.0163	1.209
1.2515	16.319	1.0081	.604
1.2453	15.814	1.0040	.302

Imitation Liquors.

The liquors generally met with for sale and consumption are, it is well known, rarely genuine; and even if genuine, are often adulterated with water and various deleterious compounds. The imitations of liquor innocently imbibed by the unsuspecting as wholesome stimulants, contain, too frequently, combinations that are most hurtful, if not actually poisonous. Receipts are here given for making imitation liquors, which are at least as wholesome as genuine spirits, and contain no ingredient that can hurt the system more than alcohol itself does. They are the receipts furnished by a practical French chemist, who has made this business a specialty for some thirty years.

664. Prune Flavoring for Liquors. Mash 25 pounds prunes, infuse for 15 days with 6 gallons proof spirit, stirring it every day; press and filter.

665. Raisin Flavoring for Liquors. Subject 25 pounds mashed raisins to the same process as the prunes in the last receipt.

666. St. John's Bread Flavoring for Liquors. Cut 50 pounds St. John's bread into small pieces. Infuse for 15 days with 12 gallons proof spirits, stirring every day; filter.

667. Orange Peel Flavoring for Liquors. Steep 1 pound orange peel in 1 gallon 95 per cent. alcohol for 15 days; filter.

668. Vanilla Flavoring for Liquors. Slice 1 drachm vanilla in small pieces; infuse for 20 days in 1 pint 95 per cent. alcohol; filter.

669. Orris Root Flavoring for Liquors. Infuse 2 ounces powdered orris root for 20 days in 1 quart 95 per cent. alcohol, and filter.

670. Sassafras Flavoring for Liquors. Granulate ½ pound sassafras bark, and infuse it in ½ gallon 95 per cent. alcohol for 20 days; filter.

671. Hickory Nut Flavoring for Liquors. Crush 1 bushel hickory nuts, and infuse for 1 month in 12 gallons 95 per cent. alcohol; strain and filter.

672. Flavoring Compound for Brandy. Mash 25 pounds raisins, 12 pounds prunes, 6 pounds figs, and 1 pineapple sliced; infuse for 15 days in 20 gallons proof spirits, stirring every day, and then filter.

673. Coffee Flavoring for Liquors. Infuse 1 pound ground roasted coffee in 1 gallon 95 per cent. alcohol. This is used in combination with other flavors for brandy.

674. Peach Flavoring for Whiskey. Steep for 1 month, 10 gallons dried peaches, 10 gallons oak saw-dust, and 5 pounds black tea in 40 gallons proof spirits; strain and filter.

675. How to Prepare Essence of Cognac. Take 1 ounce oil cognac—the green oil is the best; put it in ½ gallon 95 per cent. spirits. Cork it up tight, shake it frequently for about 3 days; then add 2 ounces strong ammonia. Let it stand 3 days longer; then place in a stone jar that will contain about 3 gallons, 1 pound fine black tea, 2 pounds prunes, having first mashed the prunes and broken the kernels. Pour on them 1 gallon spirits 20 above proof. Cover it close, and let it stand 8 days. Filter the liquor, and mix with that containing the oil and ammonia. Bottle it for use. This makes the best flavoring known for manufacturing brandies, or for adding to such cordials, syrups, &c., as require a fine brandy flavor. (*Monzert.*)

676. To Imitate Brandy with Essence of Cognac. Take 1 pint essence of cognac (*see No.* 675), 15 gallons pure spirits (very fine) 20 per cent. above proof, ½ pint plain white syrup. Color with caramel.

677. Simple Test for Alcohol in Oil of Cognac. Take a half ounce phial or test tube, and fill it *exactly* half full of oil of cognac; then fill up the remaining space with water, and shake it well. The alcohol, if there be any present, having a much greater affinity for water than for the oil, will leave the oil and combine with the water; denoting, by the decrease in the bulk of the oil, or the increase in that of the water, the quantity of alcohol present. Other tests for essential oils will be found under its heading. (*See Index.*)

678. Highly Flavored Domestic Brandy. To 40 gallons French proof spirits, add 2 quarts raisin flavoring (*see No.* 665), 2 quarts prune flavoring (*see No.* 664), 2 quarts St. John's bread flavoring (*see No.* 666), 1 gallon best sherry wine, 2 drachms oil of cognac and 20 drops oil of bitter almonds, both dissolved in a little 95 per cent. alcohol; 1 gallon Jamaica rum (or ½ ounce Jamaica rum essence), and 2 pints wine vinegar. Ten gallons of this mixture, mixed with 30 gallons French spirits, make an excellent domestic brandy, and 1 pound of glycerine gives it age.

679. Imitation Cognac Brandy. To 36 gallons French proof spirits, add 4 gallons Pellevoisin or Marette cognac, ½ gallon best sherry or Madeira wine, and 20 drops oil of cognac, dissolved in a little 95 per cent. alcohol. Then pour 2 quarts boiling water over 2 ounces black tea; when cold, filter through flannel, and add a little maraschino; mix this with the other ingredients, and color the whole to suit, with caramel. (*See No.* 694.)

Another excellent formula is as follows: Dissolve 20 drops oil of cognac and 15 drops oil of bitter almonds in a little 95 per cent. alcohol; add it to 40 gallons 60 per cent. French spirit, with 2 pints tincture of raisin, 2 pints tincture of prunes, 3 pints best Jamaica rum, 3 pints best sherry wine, and ½ ounce acetic ether. Color with caramel.

680. Imitation Brandy. Take 40 gallons French spirit; add to it 1 pint tincture of raisins (*see No.* 665), 1 quart prune flavoring (*see No.* 654), ½ gallon best sherry or Madeira wine, and 1 pint wine vinegar. Then add 1 drachm oil of cognac, 12 drops oil of bitter almonds, ½ to ½ drachm tannin powder, each dissolved separately in 95 per cent. alcohol. Color to suit with caramel. (*See No.* 694.)

681. Imitation French Brandy. To 40 gallons French proof spirit, add 1 quart tincture of orris root (*see No.* 669), 1 pint vanilla flavoring (*see No.* 668), ½ gallon best sherry or Madeira wine, and 1 pint wine vinegar. Dissolve separately, 1 drachm oil of cognac and 12 drops oil of bitter almonds, each in a little 95 per cent. alcohol, and add them to the mixture, coloring the whole to suit with caramel. (*See No.* 694.)

682. Imitation Pale Brandy. Infuse 1 drachm star-anise (breaking the star only) for 8 hours in ½ pint 95 per cent. alcohol, and filter; add this to 40 gallons proof spirits; then add ½ gallon best Jamaica rum, and 1 pint of the best raspberry syrup. Dissolve 1 drachm oil of cognac, and 12 drops oil of bitter almonds, separately, in a little 95 per cent. alcohol, and mix them with the whole.

683. Imitation Bourbon Whiskey. Mix together 40 gallons proof spirits, ¼ gallon peach flavoring (*see No.* 674), ½ gallon hickory nut flavoring (*see No.* 671), ½ gallon highly flavored brandy (*see No.* 678), 1 pint wine vinegar, and 1 pint white glycerine. Add to these 12 drops oil of cognac dissolved in 95 per cent. alcohol, and color with caramel. (*See No.* 694.)

Or: 36 gallons proof spirits, 4 gallons highly flavored proof rye whiskey, 1 gallon domestic brandy (*see No.* 680), together with the same proportions of vinegar, glycerine, and oil of cognac, as before.

684. Imitation Bourbon Whiskey. To 36 gallons proof spirits, add 4 gallons highly flavored proof Bourbon, 1 gallon New England rum, ½ gallon sweet Catawba wine (or 1 quart sherry wine), and 1 pound white glycerine. Color to suit with caramel. (*See No.* 694.)

685. Imitation Bourbon Whiskey. 36 gallons proof spirit, 4 gallons highly flavored proof Bourbon, 1 gallon malt whiskey, 1 pint wine vinegar, 1 pint syrup, and 12 drops oil of cognac dissolved in 95 per cent. alcohol. Color with caramel. (*See No.* 694.)

686. Imitation Bourbon Whiskey. To 40 gallons proof spirit, add 1 gallon hickory flavor (*see No.* 671), 1 gallon domestic brandy (*see No.* 680), 1 pint wine vinegar, and 1 pound white glycerine, with 12 drops oil of cognac dissolved in 95 per cent. alcohol, and caramel (*see No.* 694) sufficient to color.

687. Imitation Copper-Distilled Bourbon Whiskey. Dissolve 1 drachm sulphate of copper in ½ pint water, filter, and add it to 40 gallons proof spirit, with 1 gallon peach flavor (*see No.* 674), 1 gallon brandy flavor (*see No.* 672), 1 pint wine vinegar, 1 pound white glycerine, and 12 drops oil of cognac dissolved in 95 per cent. alcohol. Color with caramel. (*See No.* 694.)

688. Imitation Rye Whiskey. To 40 gallons proof spirit, add 2 gallons peach flavoring (*See No.* 674), 1 pint white vinegar, and 12 drops oil of cognac in 95 per cent. alcohol. Color with caramel. (*See No.* 694.)

689. Imitation Sweet Rye Whiskey. 30 gallons proof spirit, 10 gallons proof rye whiskey, and 1 gallon raisin flavor (*see No.* 665), colored with sufficient caramel. (*See No.* 694).

690. Imitation Irish Whiskey. 36 gallons French spirits 20 above proof, 4 gallons Scotch (Ramsay) whiskey, 3 pints best sherry wine, 2 pints syrup, and 10 drops sassafras flavor. (*See No.* 670.)

691. Imitation Scotch Whiskey. 36 gallons French spirits 20 above proof, 4 gallons Scotch whiskey, and 1 quart syrup.

692. To Impart a Smoky flavor to Whiskey. The simplest way to impart this peculiar flavor to whiskey is by preparing the barrel. Insert securely a large sheet-iron funnel into the bung-hole of a dry 40-gallon barrel; provide a small open furnace, containing a charcoal fire; put 1 pound of birch bark on the fire, and support the barrel, with its funnel downwards, over the furnace, so that the funnel, which should be considerably wider than the furnace, will receive the smoke from the bark. When the bark ceases smoking, remove the funnel and bung the barrel up tight. After it has stood 24 hours, put the spirit in the barrel, and keep it there for 36 hours, frequently rolling the barrel, in order that the spirits may be thoroughly impregnated with the smoke and smoky deposit on the inside of the barrel. The spirits will then be found to have acquired the desired flavor. Creosote, diluted with alcohol, is sometimes used to impart the smoky flavor to spirits.

693. To Give the Appearance of Age to Brandy Barrels. Dissolve in 3 gallons water, 3 pounds sulphuric acid and 1 pound sulphate of iron. Wash the barrels with it on the outside.

694. To Make Caramel. Dissolve 7 pounds crushed sugar in 1 pint water; boil it in a 5-gallon copper kettle, stirring occasionally until it gets brown; then reduce the fire and let the sugar burn until the smoke makes the eyes water. When a few drops, let fall into a tumbler of cold water, sink to the bottom and harden sufficiently to crack, it is done. Then pour on it, by degrees, about 2 quarts warm water, stirring all the time. When well mixed, filter it hot through a coarse flannel filter. Some use lime-water to dissolve the burnt sugar. Care must be taken not to overburn it, as a greater quantity is thereby rendered insoluble. The heat should not exceed 430°, nor be under 400° Fahr. The process for nice experiments is best conducted in a bath of melted tin, to which a little bismuth has been added, to reduce its melting point to about 435°; a little powdered resin or charcoal, or a little oil, being put upon the surface of the metal, to prevent oxidation.

695. To Plaster Brandy Pipes. First notch over the bottom of the casks with a hatchet or adze; then, for the bottom of a ½ pipe mix ½ gallon plaster with 1 gallon water, and pour it on; while the plaster is setting, tap the cask gently with a mallet, in order that the plaster may penetrate into every crevice. When the plaster is fully set, wash it over with a wet sponge. If you wish to color the plaster, add a little Venice red.

696. Wax Putty for Leaky Casks, Bungs, &c. Melt 8 pounds yellow wax and 12 pounds solid turpentine over a slow fire; add 4 pounds tallow; and, when thoroughly mixed, remove the whole to a distance from the fire and stir in 2 pounds spirits of turpentine, and let it cool.

697. Imitation Schiedam Gin. Dissolve 3½ drachms oil of juniper in sufficient 95 per cent. alcohol to make a clear liquid; add it to 40 gallons French spirits 10 above proof, with 8 ounces orange peel flavoring (*see No.* 667), 1 quart syrup, and 30 drops oil of sweet fennel.

698. Imitation Old Tom London Gin. Dissolve in 1 quart 95 per cent. alcohol, 1 drachm oil of coriander, 1 drachm oil of cedar, ½ drachm oil of bitter almonds, ½ drachm oil of angelica, and ½ drachm oil of sweet fennel; add it to 40 gallons French spirit 10 above proof, with 1 pint orange-flower water, 1 quart syrup, and 1 drachm oil of juniper dissolved in sufficient 95 per cent. alcohol to be clear.

699. Imitation Santa Cruz Rum. 35 gallons New England rum, 5 gallons Santa Cruz rum, and 1 drachm vanilla flavoring. (*See No.* 668.)

700. Imitation Batavia Arrack. 35 gallons French spirit (rice spirit is preferable), 5 gallons Batavia arrack, ½ ounce balsam of tolu, and ½ ounce tincture of flowers of benzoin.

701. Imitation Batavia Arrack. To 12 gallons pale rum add 2 ounces flowers of benzoin, 1½ ounces balsam of tolu, 1 sliced pineapple. Digest with occasional agitation for a month; then add ½ pint raw milk. Agitate well for 15 minutes, and rack in a week. A fine imitation.

702. Imitation Jamaica Rum. 20 gallons spirit 10 above proof, 20 gallons New England rum 10 above proof, ½ pound Jamaica rum essence, 1 gallon St. John's bread flavoring (*see No.* 666), and 1 pound white glycerine. Color to suit with caramel. (*See No.* 694.) Or:—40 gallons spirit 10 above proof, 1 pound Jamaica rum essence, 10 drops oil of cloves, 1 gallon St. John's bread flavoring (*see No.* 666), and 1 pound white glycerine. If desired, there may be added 1 ounce gum kino and ½ drachm oil of caraway, each dissolved in 2 ounces 95 per cent. alcohol.

703. To Make Spirit Finings. Pulverize 1 pound ordinary crystals of alum, divide into 12 equal portions, and put up in blue papers marked No 1. Next take 6 ounces carbonate (the ordinary sesquicarbonate) of soda, divide it into 12 parts and put them up in white papers marked No. 2. In place of the 6 ounces carbonate of soda, 4 ounces dry salt of tartar may be substituted, but the white papers containing this latter substance must be kept in a dry, well corked bottle or jar.

704. To Clarify Gin or Cordials. To clarify from 30 to 36 gallons gin, dissolve the contents of one of the blue papers, as prepared in No 703, in about a pint of hot water, and stir it into the liquor thoroughly. Then dissolve the contents of one of the white papers in about ½ pint hot water, and stir well into the liquor; bung the cask close, and let the whole remain till the next day.

705. To Blanch Gin or other White Liquor. By using double the quantity of finings, that is, 2 of each of the powders, as laid down in the foregoing receipt, the liquor will be blanched as well as clarified. It is well to recollect, however, that the more finings are employed, the greater the risk of injuring the liquor, which may have a tendency to become flat when "on draught."

706. Finings for Gin. To 100 gallons gin, take 4 ounces roche alum, and put it into 1 pint of pure water; boil it until it is dissolved, then gradually add 4 ounces salts of tartar; when nearly cold put it into the gin, and stir it well with a staff for 10 minutes. The liquor must not be covered until it is fine; when this is accomplished, cover it up tight to prevent it from losing its strength.

707. To Remove the Blackness from Gin. Some gin has a particular blackness; to remove which, take 1 ounce pulverized chalk and 2 or 3 ounces isinglass, dissolved; put this into the gin and it will become transparent. The above is enough for 10 gallons. The blackness which gin sometimes contracts by coming in contact with iron, may also be carried down by putting a solution of 2 ounces isinglass and 1 quart skimmed milk into the spirit. When the color is very black, which will happen by merely an iron nail having fallen into the liquor, there is no remedy but to have the liquor distilled over again.

708. To Clarify Stained Gin. When gin has once become much stained, the only remedy is to re-distill it; when it is only slightly stained the addition of a few pounds acetic acid to a pipe or butt, 1 or 2 spoonfuls to a gallon, or a few drops to a decanterful, will usually decolor it.

709. Brandy Filter. When necessary to filter an imitation brandy, an excellent utensil may be used for that purpose which has already been described. (*See No. 17, fig.* 5.) It will, however, be necessary to substitute cotton wadding in place of the charcoal.

710. To Make Rum Punch. Dissolve in 1 pint 95 per cent. alcohol, 3 drachms oil of lemon, and ½ drachm oil of cloves; infuse 3 ounces ground allspice for 10 days in 1 quart 95 per cent. alcohol, and filter it. Mix these with 18 gallons spirit 30 above proof, 2 gallons Jamaica rum, and 1 pound Jamaica rum essence (or 20 gallons New England rum 30 over proof and ½ pound Jamaica rum essence). Next add 2½ pounds tartaric acid dissolved in 2½ gallons water, and 18 gallons syrup made of 108 pounds white sugar. Color with caramel. (*See No.* 694.)

711. To Make Wine Punch. Dissolve 2½ drachms oil of lemons and ½ drachm oil of cloves in 95 per cent. alcohol; make an infusion of 3 ounces ground allspice, as in last receipt; add these to 10 gallons proof spirit, 10 gallons Marsala or Catalonia wine, 10 gallons syrup made of 35 pounds white sugar, and ½ pound tartaric acid. If not red enough, add a little cherry juice. Filter.

712. To Make Wine Punch. To 10 gallons proof spirit, add 10 gallons Marsala or Catalonia wine. Take 10 gallons syrup made of 35 pounds sugar; peel the rind, thinly, of 120 lemons; bring the syrup to a boil, and simmer the lemon rinds in it for ½ hour or more, then strain it through a fine flannel. Mix all the above with the juice of the lemons. Instead of boiling the lemon peel in the syrup, it may be infused for 5 or 6 days in 95 per cent. alcohol. The color can be deepened with cherry juice. Brandy, rum, whiskey and arrack punch may be made as above, substituting the liquor for the wine and spirits.

Champagne.

The process of making American and imitation French champagne is one requiring great care, especially in producing a not only clear, but bright wine. Full directions are given below for making the necessary syrup, mixing the ingredients, fining, filtering and gassing; including a number of receipts for different kinds of champagne. A careful attention to the instructions laid down will produce wines which will compare favorably with the best genuine importations.

714. To Make a Filter for Filtering Wines. A filter for wines is usually made of felt, shaped like a cone or sugar loaf; those without any seam are the best. A lining of paper pulp is prepared in the following manner: Tear from 2 to 4 sheets filtering paper into small pieces and put it into a pail; pour over it a little boiling water, sufficient, by thorough beating, to form a fine smooth paste; then add sufficient water to fill the filter. Pour this quickly into the filter, and, 5 minutes after the water has drained through, fill up with the wine to be filtered, taking care to keep the filter always full.

715. To Make Syrup for Champagne Wine. To 25 pounds white sugar, add 2 gallons water and the whites of 4 eggs; stir until the sugar is dissolved. Let the whole simmer to the candy degree; then strain it through a bag made of fine flannel.

716. To Prepare Isinglass for Fining Wines. Cut up some isinglass (it must be of the very best quality), and put it in a jar, with just enough wine or water to cover it; add daily as much of the wine or water as has been absorbed by the isinglass. In 6 or 8 days it should be completely dissolved, forming a thick fluid mass. Squeeze it through a linen cloth and put it into a bottle, adding 4 or 5 per cent. of 95 per cent. alcohol to make it keep. For 40 gallons wine to be fined, take 1 wine-glassful of dissolved isinglass, add a little wine and a pinch of salt, and beat to a froth with a whisk, adding by degrees sufficient wine to make the mixture up to ¼ gallon. When foaming, pour it slowly into the wine, stirring till all the fining is incorporated with the wine. Isinglass thus prepared and used will precipitate completely; and, after a few days, the wine will be bright. Too much care cannot be taken in the preparation of fining, as even the finest isinglass contains fibrous matter which dissolves with difficulty; this is very apt to remain suspended in the wine, and is not visible until developed, after bottling, by the gas with which the wine is afterwards charged.

717. To Prepare Champagne Wine for Charging. Put the wine used to make the champagne into a cask, add the brandy spirit, the aroma or flavoring, and the syrup, and stir for 10 minutes. Every day for 4 days draw off 15 or 20 gallons of the mixture and pour it in again; let it rest 4 days more, then add the fining, stir for 10 minutes, and bung up the cask. In 3 or 4 days, if bright, draw off slowly, so as not to disturb the lees. Filter (*see No.* 714), and it is ready for the fountain of the gassing apparatus.

718. To Charge Champagne with Gas. Matthews' apparatus is the one usually adopted in the United States for generating the gas and charging champagne wine. The fountains, tubes, and valves are silver-lined, and the machines are adapted for pint and quart bottles. The following is a proper charge for a No. 2 apparatus with 2 fountains: Charge the generator with 9 gallons water, 6 gallons ground marble, and 3 gallons sulphuric acid; put 2 gallons water in the gas washer, and 20 gallons wine in each of the fountains. For a warm climate, a pressure of 70 pounds to the square inch is sufficient. When the wine is made in winter for immediate sale, the pressure may be increased to 80 pounds. Genuine champagne has an average pressure of 50 pounds.

719. Catawba Champagne. Take 40 gallons Catawba wine; ¼ gallon old cognac brandy; and 4 gallons syrup made of 30 pounds sugar and 2 gallons water according to No. 715;—or, 38 gallons Catawba wine; 2 gallons Angelica wine, and 4 gallons syrup as above. A very little tincture vanilla added to either of these makes a fine bouquet.

720. California Champagne. 40 gallons California wine; 1 quart raspberry syrup (*see No.* 1372); 4 gallons syrup made of 25 pounds sugar and 2 gallons water (*see No.* 715); and 4 gallons water. Or: 20 gallons California wine; 20 gallons Sauterne or white Bordeaux wine; ¼ gallon old cognac brandy; with 4 gallons syrup as before. Add to these 10 per cent. of water.

721. Scuppernong Champagne. 40 gallons Scuppernong wine; ¼ gallon old cognac brandy; and 3 gallons syrup made of 20 pounds sugar (see *No.* 715) and 2 gallons water.

722. Imitation French Champagne. 40 gallons white Bordeaux wine; 1 gallon muscat wine; ¼ gallon old cognac brandy; and 4 gallons syrup made of 25 pounds sugar and 2 gallons water. (*See No.* 715). In this receipt a little tincture of vanilla, or a small bottle of bouquet venatique, may be used instead of the muscat wine. They may be omitted altogether if aroma is not desired.

723. Cheap Champagne. 13 gallons California wine; 13 gallons white Bordeaux wine; 13 gallons water; 1 gallon 95 per cent. French spirit; 1 quart raspberry syrup (*see No.* 1372); and 4 gallons syrup made of 25 pounds sugar and 2 gallons water. (*See No.* 715.) Or: 20 gallons Catawba wine; 20 gallons water; 2 gallons Angelica wine; 2 gallons 95 per cent. French spirit, and 4 gallons syrup as before.

724. Cheap Champagne. 20 gallons white Bordeaux wine; 20 gallons German or Hungarian wine; 20 gallons water; 2 gallons 95 per cent. French spirit; and 6 gallons syrup made of 35 pounds sugar and 3 gallons water. (*See No.* 715.)

725. The Use of Glycerine in Wine. Glycerine differs from sugar in not fermenting or taking any active part in the process of fermentation. It can, therefore, be made use of after fermentation, to impart any required degree of sweetness to wine, without the risk of further fermentation, as is the case with sugar when used for this purpose; it is said that it can be added with perfect safety to even a young or new wine, as soon as it has become clear. It is absolutely necessary that the glycerine should be chemically pure; care is consequently to be taken in purchasing it, as there are few articles in the market which are liable to contain so many impurities. (*See No.* 1151.) The proportion of glycerine should be from 1 to 3 gallons for 100 gallons of wine, according to the quality of the latter. If the wine is perfectly clear before adding the glycerine it will be ready for bottling at once. It is best to mix the glycerine first with an equal quantity of the wine, and then add the mixture to the remainder of the wine.

726. Electricity as an Agent for improving Whiskey and Wines. From experiments made on a large scale, it has been found that electricity in any form, either as a regular current or a succession of discharges, renders wine or whiskey mellow and mature. It is supposed that the bitartrate of potassa is decomposed, setting free potash and tartaric acid: the former tending to neutralize the acids of the wine; and the tartaric acid, reacting upon the fatty matters present, favors the formation of the ethers which constitute the bouquet of the wine. It is probable, also, that a small quantity of the water is decomposed, setting free oxygen, which forms, with some of the constituents of the wine, new compounds peculiar to old wines. (*See No.* 6295.)

Home-Made Wines.

The various processes in domestic wine-making resemble those employed for foreign wine, and depend upon the same principles. The fruit should be preferably gathered in fine weather, and not till it has arrived at a proper state of maturity, as evinced by its flavor when tasted; for if it be employed while unripe, the wine will be harsh, disagreeable, and unwholesome, and a larger quantity of sugar and spirit will be required to render it palatable. The common practice of employing unripe gooseberries for the manufacture of wine arises from a total ignorance of the scientific principles of wine-making. On the other hand, if fruit be employed too ripe, the wine is apt to be inferior, and deficient in the flavor of the fruit. The fruit being gathered, it next undergoes the operation of picking, for the purpose of removing the stalks and unripe or damaged portion. It is next placed in a tub, and well bruised. Raisins are commonly permitted to soak about 24 hours previously to bruising them, or they may be advantageously bruised or minced in the dry state. The bruised fruit is then put into a vat or vessel with a guard or strainer placed over the tap-hole, to keep back the husks and seeds of the fruit when the must or juice is drawn off. The water is now added, and the whole macerated for 30 or 40 hours, more or less; during which time it is frequently stirred up with a suitable wooden stirrer. The liquid portion is next drawn off, and the residuary pulp is placed in hair bags and undergoes the operation of pressing, to expel the fluid it contains. The sugar, tartar, &c. (in very fine powder, or in solution), are now added to the mixed liquor, and the whole is well stirred. The temperature being suitable (generally from 75° to 85° Fahr.), the vinous fermentation soon commences, when the liquor is frequently skimmed (if necessary) and well stirred up, and, after 3 or 4 days of this treatment, it is run into casks, which should be quite filled, and left open at the bung-hole. In about a week the flavoring ingredients, in the state of coarse powder, are commonly added, and well stirred in, and in about another week, depending upon the state of the fermentation and the attenuation of the must, the brandy or spirit is added, and the cask filled up, and bunged down close. In 4 or 5 weeks more the cask is again filled up, and, after some weeks—the longer the better—it is "pegged" or "spiled," to ascertain if it be fine or transparent; if so, it undergoes the operation of racking; but if, on the contrary, it still continues muddy, it must previously pass through the process of fining. Its future treatment is similar to that of foreign wine. The must of many of the strong-flavored fruits, as black currants, for instance, is improved by being boiled before being made into wine; but the flavor and bouquet of the more delicate fruits are diminished, if not destroyed, by boiling.

728. General Receipt for the Preparation of Home-Made Wine from Ripe Saccharine Fruits. I. Ripe fruit, 4 pounds; clear soft water, 1 gallon; sugar, 3 pounds; cream of tartar, dissolved in boiling water, 1½ ounces; brandy, 2 to 3 per cent. Flavoring as required. Makes a good family wine. II. As the last, using 1 pound more each of fruit and sugar. A superior wine.

III. As the first, adding 2 pounds each fruit and sugar. Very strong. Is good without brandy, but better with it. 1¼ pounds of raisins may be substituted for each pound of sugar above. In the above way may be made the following wines:—gooseberry wine, currant wine (red, white or black); mixed fruit wine (currants and gooseberries; or black, red, and white currants, ripe black-heart cherries, and raspberries, equal parts). This is a good family wine. Cherry wine; Colepress's wine, (from apples and mulberries, equal parts); elder wine; strawberry wine; raspberry wine; mulberry wine (when flavored makes port); whortleberry (sometimes called huckleberry) wine; makes a good factitious port; blackberry wine; morella wine; apricot wine; apple wine· grape wine, &c.

729. General Receipt for Making Wine from Dry Saccharine Fruit. I. Dry fruit, 4¼ pounds; soft water, 1 gallon; cream of tartar (dissolved), 1 pound; brandy, 1½ to 2 per cent., weak.

II. As the last, but using 5½ pounds dried fruit. A superior family wine.

III. As the last, 7½ pounds fruit, and brandy 3 per cent. A strong wine. Should the dried fruit employed be at all deficient in saccharine matter, 1 to 3 pounds may be omitted, and half that quantity of sugar, or two thirds of raisins, added. In the above manner may be made raisin wine, fig wine, &c.

730. Imitation Champagne. Stoned raisins, 7 pounds; loaf sugar, 21 pounds; water, 9 gallons; crystallized tartaric acid, 1 ounce; honey, ½ pound; ferment with sweet yeast 1 pound or less; skim frequently, and when the fermentation is nearly over, add coarse-powdered orris root, 1 drachm, and eau de fleurs d'orange, 3 ounces; lemon juice, ½ pint. Rack it, bung close, and in 3 months fine it down with isinglass, ½ ounce; in 1 month more, if not sparkling, again fine it down, and in 2 weeks bottle it, observing to put a piece of double-refined sugar, the size of a pea, into each bottle. The bottles should be wired, and the corks covered with tin foil.

731. To Make Blackberry Wine. To make 10 gallons of this cheap and excellent wine, press the juice out of sufficient fresh ripe blackberries to make 4½ gallons; wash the pomace in 4½ gallons soft spring water, and thoroughly dissolve in it 6 pounds white sugar to each gallon of water (brown sugar will do for an inferior wine); strain the juice into this syrup, and mix them. Fill a cask with it perfectly full, and lay a cloth loosely over the bung-hole, placing the cask where it will be perfectly undisturbed. In two or three days fermentation will commence, and the impurities run over at the bung. Look at it every day, and if it does not run over, with some of the mixture which you have reserved in another vessel fill it up to the bung. In about three weeks, fermentation will have ceased, and the wine be still; fill it again, drive in the bung tight, nail a tin over it, and let it remain undisturbed until the following March. Then draw it off, without shaking the cask, put it into bottles, cork tightly and seal over. Some persons add spirit to the wine, but instead of doing good, it is only an injury. The more carefully the juice is strained, the better the quality of the sugar, and the more scrupulously clean the utensils and casks, the purer and better will be the wine.

732. Cider Wine. Let the new cider from sour apples (ripe, sound fruit preferred), ferment from 1 to 3 weeks, as the weather is warm or cool. When it has attained to a lively fermentation, add to each gallon, according to its acidity, from ½ to 2 pounds white crushed sugar, and let the whole ferment until it possesses precisely the taste which it is desired should be permanent. In this condition pour out a quart of the cider and add for each gallon ½ ounce of sulphite (not sulphate) of lime. Stir the powder and cider until intimately mixed, and return the emulsion to the fermenting liquid. Agitate briskly and thoroughly for a few moments, and then let the cider settle. Fermentation will cease at once. When, after a few days, the cider has become clear, draw off carefully, to avoid the sediment, and bottle. If loosely corked for a short time, it will become a sparkling cider wine, and may be kept indefinitely long.

733. Honey or Mead Wine. Honey, 20 pounds; cider, 12 gallons; ferment, then add rum, ½ gallon; brandy, ½ gallon; red or white tartar (dissolved), 6 ounces; bitter almonds and cloves, of each ½ ounce. The process of fermenting, clearing and bottling, is similar to the last receipt.

734. Specimen Process to Make Unripe Grape, Currant, Gooseberry and Rhubarb Wine, according to the process of Dr. McCulloch. Gather the fruit when it is nearly full grown, but before it shows the least sign of ripening. Any kind will do, but it is advisable to avoid choosing those which, when ripe, would be highly flavored. All unsound and bruised fruit should be rejected, and the stalks and remains of blossom removed by picking or rubbing. The following receipt is one of the best on the subject: 40 pounds fruit are to be bruised in small quantities, in a tub which will hold 15 or 20 gallons, sufficient pressure only being used to burst the berries, without breaking the seeds or much compressing the skins. 4 gallons water are then to be poured on the fruit, which is to be carefully stirred, and squeezed with the hands until the whole of the juice and pulp are separated from the solid matter. It is then to rest for a few hours, when it must be pressed and strained through a coarse canvas bag with considerable force. 1 gallon water may afterwards be passed through the residue, to remove any soluble matter that may be left, and then added to the juice. 30 pounds loaf sugar are now to be dissolved in the juice, and the total quantity of liquid made up with water to 10½ gallons. The liquor is now to be put into a tub, over which spread a blanket, covered by a board, and place in a temperature of from 55° to 60° Fahr. for from 24 to 48 hours, according to the signs which it may show of fermentation, when it is to be put into a cask to ferment. The cask must be of such size that the liquor will nearly reach to the bung-hole, so that the scum may run out as it rises. As the fermentation goes on the liquor will decrease, and the cask must be kept filled up nearly to the bung-hole with a portion of the "must" which has been reserved for that purpose. When the fermentation has become a little weaker, which may be known by the hissing noise decreasing, the bung is to be driven in, and a wooden peg, called a spile, made of tough wood, put into a hole bored in the top of the barrel. After a few days this peg is to be loosened to let out any carbonic acid gas which has been generated. This must be done from time to time, and when there is no further sign of gas generating to the danger of the barrel, the spile may be made tight. The wine should be kept during the winter in a cool cellar, and, if fine, may be bottled on a clear cold day at the end of February or the beginning of March, without further trouble. But to ensure its fineness it is preferable to draw it off at the end of December into a fresh cask, so as to clear it from the lees. At this time, also, if it is found to be too sweet for the maker's taste, he should stir up the lees so as to renew the fermentation, at the same time raising the temperature. When it is transferred to the fresh cask, it should be fined with isinglass. Sometimes it is desirable to rack it off a second time into a fresh cask, again fining it. All these removals should be made in clear, dry, and if possible, cold weather. It must be bottled in March. This wine will usually be brisk, but circumstances will occasionally cause it to be sweet and still, and sometimes dry. If sweet, it may be re-made the following season, by adding to it juice from fresh fruit, according to the degree of sweetness, and fermenting and treating it as before. But if it be dry, briskness can never be restored, and it must be treated as a dry wine, by drawing it off into a cask previously fumigated with sulphur (*see No. 765*), and fining and bottling it in the usual manner. Such dry wines sometimes taste disagreeably in the first and second year, but improve much with age. If the whole marc or husks, etc., is allowed to remain in the juice during the first fermentation, the process will be more rapid, and the wine stronger and less sweet; but it will have more flavor. If the wine is desired to be very sweet as well as brisk, 40 pounds of sugar may be used; less sweet and less strong, 25 pounds; it will be brisk, but not so strong, and ought to be used within a year.

735. Ripe Gooseberry Wine. Put the ripe and well picked red gooseberries into a tub or pan, bruise the fruit well, and leave it uncovered for 24 hours. Squeeze the juice from the pulp through a hair or canvas bag. Put the residue of each squeezing into a vessel; pour upon it ½ gallon of boiling water for each gallon of fruit used, and stir well for a quarter of an hour. Let it stand for 12 hours, squeeze the pulp through the bag, and add the liquor to the juice of the fruit obtained. Add 2½ pounds sugar to each gallon of the liquor, and stir it well. Let it stand to ferment. When it has done fermenting, draw it off and add ¾ pint brandy to each gallon. Let it stand to settle for 4 or 5 weeks, then draw it off carefully into a cask that will just hold it; keep it in a cool cellar for twelve months or more, when it may be bottled. Choose a clear, dry, cold day. It ought to be a splendid wine in 2 years.

736. Ginger Wine. Boil 20 pounds sugar in 7 gallons water for half an hour, skimming it well; then put 9 ounces bruised ginger in a portion of the liquor, and mix all together. When nearly cold, put 9 pounds raisins, chopped very small, into a nine-gallon cask, add 4 lemons sliced, after taking out the seeds, and pour the liquor over all, with ½ pint yeast. Leave the cask open for 3 weeks, keeping it filled up with some of the reserved liquor, and bottle it in from 6 to 9 months.

737. Ginger Wine. Another Process. Boil 26 pounds raw sugar in 7 gallons water for half an hour, skimming it well; then, if the syrup is quite clear from scum, pour it boiling upon 8 ounces bruised ginger and 16 lemons sliced; when the whole has cooled down to about 75°, squeeze out the lemons and ginger through a sieve, and add the yeast. Let it work for about 3 days, and then draw it off into a cask. Put half of the lemon and ginger residue in with it. Some first pare the lemons, and having rubbed the rinds with loaf sugar, add the latter when it is done working. Bottle in 3 months.

738. To Make Aromatic Ginger Wine. Reduce the following to coarse powder: 5 pounds Jamaica ginger root, 6 to 8 ounces cloves, 1 pound allspice, ¼ pound cinnamon, and ½ pound mace. Infuse these for 10 days in 10 gallons 95 per cent. spirit, stirring every day, and then filter. Then dissolve 60 pounds white sugar in 85 gallons water; mix the whole together, and color with cherry juice; then filter.

739. To Make Ten Gallons of Ginger Wine. Boil ¾ pound best white Jamaica ginger, bruised, in about 8 gallons water; add the whites of 6 eggs to ½ ounce isinglass, 15 pounds loaf sugar, and the rinds of 6 lemons; boil the compound ¾ of an hour, and skim it clean; when nearly cold put it into a vessel that will admit of its being drawn off; set it to work with yeast, and in a few days afterwards draw it off into a cask; then add the juice of the 6 lemons, and 2 quarts spirits; in a week or ten days bung the cask closely, and when thoroughly fine, bottle the wine off. It will be fit to drink in 4 months.

740. Simple Receipt for Making Grape Wine. Put 20 pounds of ripe, fresh-picked, and well selected grapes into a stone jar, and pour on them 6 quarts boiling water; when the water has cooled enough, squeeze the grapes well with the hand; cover the jar with a cloth, and let it stand for 3 days; then press out the juice, and add 10 pounds crushed sugar. After it has stood for a week, scum, strain, and bottle it, corking loosely. When the fermentation is complete, strain it again and bottle it, corking tightly. Lay the bottles on their side in a cool place.

741. Fine Grape Wine. In order to make good wine it is necessary to have a good cellar, clean casks, press, etc. First of all, have your grapes well ripened; gather them in dry weather, and pick out carefully all the unripe berries, and all the dried and damaged ones; then mash them; or, if you have a proper mill for the purpose, grind them. Be careful not to set the mill so close as to mash the seed, for they will give a bad taste to the wine. If you wish to have wine of a rose color, let the grapes remain in a large tub a few hours before pressing. The longer time you leave the grapes before pressing, after they are mashed, the more color the wine will have. For pressing the grapes, any press will answer, provided it is kept clean and sweet. After you have collected the must in a clean tub from the press, transfer it into a cask in the cellar. Fill the cask within 10 inches of the bung; then place one end of a syphon, made for that purpose, in the bung, and fix it air-tight; the other end must be submerged fully 4 inches in a bucket of cold water. The gas thus passes off from the cask, but the air is prevented from coming in contact with the wine, which would destroy that fine grape flavor which makes Catawba wine so celebrated. When properly made, the must will undergo fermentation. When it has fermented, which will be in 15 days, fill the cask with the same kind of wine and bung it loosely for 1 week; then make it tight. Nothing more is needed till it is clear, which, if all is right, will be in the January or February following. Then, if perfectly clear, rack it off into another clean cask, and bung it up tightly until wanted. If the wine remains in the cask till about November, it will improve by racking it again. Be sure to have sweet, clean casks. Do not burn too much brimstone in the cask (*see No. 736*); much wine is injured by excessive use of brimstone—a mistake generally made by new beginners. Different qualities of wine can be made with the same grape by separating the different runs of the same pressing. The first run is the finest to make use of the first season; but it will not keep long without losing its fine qualities. To make good sound wine, that will improve by age, the plan is to mix all up together. The very last run will make it rough, but it will have better body and better flavor when 2 or 3 years old, and will improve for a number of years. The first run will not be good after 2 or 3 years.

742. To Fine Wine Difficult to Clarify, or Thick in Consequence of an Imperfect Fermentation. To clarify 100 gallons, take 1 ounce of the species of Dock or Rumex plant, called Patience root, which boil in 1 quart water. When cold, filter, and add 1 ounce common salt, then 1 glass sheep's blood. Beat all the ingredients well together with a broom until the mixture foams up well, then add it gradually to the wine, stirring continually while pouring it in, and for 15 minutes afterwards. In a few days the wine will be clear.

743. To Fine Madeira or any kind of Wine with Isinglass. To fine 40 gallons wine, steep 1 ounce isinglass in 1 pint of pure cold water over night, and then melt it over a gentle charcoal fire, until a uniform gelatinous mass is formed. When cool, mix with it 3 pints wine, and let it repose 12 hours in a moderately warm room. Then add 1 gallon wine and mix the whole in a wooden vessel; whisk it with a clean broom until it foams up. Pour this mixture gradually in the wine you desire to fine, being careful to stir the whole continually during the process. Bung up the cask, and in the course of 48 hours the wine will appear perfectly clear and bright. Isinglass prepared in this way will precipitate perfectly, and leave no particles suspended in the wine.

744. To Fine White Wine with Eggs. To fine 60 gallons white wine, take the whites of 5 or 6 fresh eggs, 1 egg-shell nearly reduced to powder, and a small handful of common salt. Beat the whole together in a little of the wine, with a small clean broom, until it foams, then pour it into the wine gradually, constantly stirring it all the while.

745. To Fine Red Wine. This is clarified in the same way. When you have Roussillon, or the dark wines called vin du midi, which are usually of a deep color, and wish to make it of a lighter color, add 5 or 6 eggs, yellows, whites, and shells together, with a small handful of salt.

746. To Fine a Pipe of Port Wine. Take the whites and shells of ten good eggs, and beat them up to a froth in a wooden bucket; add 1 gallon of Port and whisk it well up to a froth with a clean broom; draw off 4 gallons, and put the finings in it; stir it up well, leaving out the bung one day; then bung it up, and in ten days it will be fit to bottle. If the weather be warm, mix up 1 pint silver sand and add to the finings.

747. To Fine Wine, Cider, Ale, or Porter. Take 1 pound finely shredded isinglass, and macerate it in wine, sour beer, cider, or vinegar; add more of the liquid as the isinglass swells, until about a gallon has been used, agitation with a whisk being occasionally had recourse to, for the purpose of promoting the solution. As soon as the whole of the isinglass is dissolved, the mixture is reduced to the consistence of thin syrup, with wine or the liquid that the finings are intended for. The whole is next strained through a cloth or hair sieve, and at once reduced to a proper state of dilution, by the addition of more liquor. A pound of good isinglass will make 10 to 12 gallons of finings. 1 to 1½ pints is the usual quantity for a barrel of ale or porter; and 1 quart for a hogshead of wine or cider.

748. To Decolor Wine. The color of wine is subject to change; naturally it is precipitated by age and exposure to the light; artificially it is removed by the action of lime-water, skimmed milk, milk of lime, and sometimes fresh-burnt charcoal. Wines that have acquired a brown color from the cask, or red wines that have become "pricked" (*see No. 752*), or dark wines of any kind, may easily be turned into white wine by employing either of the above substances. In this way brown Sherry is commonly changed to pale Sherry; for this purpose 2 or 3 pints of skimmed milk are generally sufficient to decolor a cask of wine; but when it is found necessary to change the color of red wine, 2 or 3 quarts or more will be required. Charcoal is not often used, as it affects the flavor as well as color of wine. A little milk of lime may sometimes be substituted for milk, especially when the wine to be decolored is very acid, and red wines may be rendered quite colorless by it.

749. To Remedy Ropiness in Wine. The peculiar cloudy, stringy, oily appearance in wine, called by the French "graisse," and by the Americans "ropiness," is occasioned by the presence of a glutinous substance, and is generally observed in those white wines which do not contain much tannin. M. Francois, a chemist, first discovered the cause, and pointed out the proper remedy, in the addition of tannin. He recommended the use of 1 pound of the bruised berries of the mountain ash in a somewhat unripe state, well stirred in each barrel of the wine to be improved. After agitation, the wine is to be left to repose a day or two, and then racked off. The tannin in the berries by this time will have separated and precipitated the glutinous matter from the liquid, and removed the ropiness. Wines thus affected cannot be fined in the regular way, as they do not contain sufficient of the astringent principle to cause the coagulation or precipitation of the finings; this principle must therefore be supplied, and for pale white wines, which are the kind chiefly attacked with ropiness, nothing equals a little pure tannin or tannic acid dissolved in proof spirit. Red wines contain so much tannic acid that they are never troubled by ropiness. Wine, after having been cured of ropiness, should immediately be fined and bottled.

750. To Ripen Wine. Dealers adopt various ways to hasten the ripening of wine. One of the safest and best plans for this purpose, especially for strong wines, is to let them remain on the lees 15 to 18 months before racking off, or, whether "crude" or "racked," keeping them at a temperature ranging between 50° to 60° Fah., in a cellar free from draughts, and not too dry. Dealers sometimes remove the bungs or corks, and substitute bladders fastened air-tight. Bottled wine treated in this way, and kept at about 70° Fah., ripens very rapidly. 4 or 5 drops of acetic acid added to a bottle of some kinds of new wine, immediately gives it the appearance of being 2 or 3 years old.

751. To Remedy Sour Wine. The souring of wine is produced by various circumstances, sometimes from its having been kept in a warm cellar where it has been exposed to draughts of air, often by the vibration occasioned by the rolling of heavy bodies over the cellar; but most frequently it originates from the wine having been imperfectly fermented. The only safe remedy for the souring of wine is the cautious addition of a little neutral tartrate of potash; it may also be mixed with a larger quantity of rich wine of its kind, at the same time adding a little good brandy. Wine treated in this way should be fined after having stood 2 or 3 weeks, and then immediately bottled, and consumed as soon as possible, for it will never prove a good keeping wine. (*See No.* 761.)

752. To Restore Pricked or Decaying Wine. If the wine is only thick, add 2 pints of milk to every 30 gallons of wine, and stir 10 minutes. But if the wine has an inferior taste, or is partly or entirely spoiled, treat it as follows: Put the 30 gallons wine into a clean cask, then take 2 pints spirit of wine, 95 per cent.; 3 ounces common salt; 1 pound white sugar. Dissolve the salt and sugar in ¼ gallon of the wine, and add the spirit. Then pour the whole gradually into the wine, being careful to stir it continually with a stick during the operation. After the mixture is all poured in the wine, stir the whole for 10 minutes longer. Then add 2 pints milk and continue stirring 10 minutes more. After some days the wine will be completely clarified and restored. "Pricked" wine signifies wine which has been slightly soured.

753. To Remedy Excessive Acidity in German Wine. Simply add a little chalk. This mode of correcting the sourness of wine is perfectly harmless, whereas the pernicious practice of using white and vitrified lead for this purpose cannot be too much condemned. Lead in any form is a poison.

754. To Restore Sour Wine with Potash. To 25 gallons wine, add 4 ounces potash dissolved in a little water, and stir well with a stick for 10 minutes.

755. To Test Wines Beginning to Decompose. Many persons are unaware of the difference between a wine that is beginning to decompose (called in French the Poux), and that in which the acetous fermentation has commenced. The Poux appears at the bottom of the barrel, while acetification begins at the top. For the first stage of the Poux the wine becomes thick, and has a peculiar taste termed flat. For the second stage the wine becomes still more troubled, and has the taste of stagnant water. Finally, in the last stage, when the decomposition has reached its maximum, the wine becomes grayish and appears like muddy water. If some of the wine is put into a champagne glass and a pinch of tartaric acid is added, a red color will be produced, which will not be the case if the wine is in a state of acetous fermentation.

756. Remedy for Decomposition in Wines. As soon as discovered add tartaric acid in the proportion of 1½ ounces to every 20 gallons of the wine, and let it rest for a few days, when, if the wine has not regained its natural color, a little more tartaric acid must be added.

757. Sweating In and Fretting In Wine. The technical terms "sweating in" and "fretting in" are applied to the partial production of a second fermentation, for the purpose of mellowing down the flavor of foreign ingredients (chiefly brandy) added to wine. For this purpose 4 or 5 pounds sugar or honey, with a little crude tartar (dissolved), are commonly added per hogshead; and when the wine is wanted in haste, 1 or 2 spoonfuls of yeast, or a few bruised vine leaves are also mixed in, the cask being placed in a moderately warm situation until the new fermentation is established, when it is removed to the wine-cellar, and, after a few days, fined down.

758. To Remove Mustiness from Wine. The disagreeable taste in wine, generally known as mustiness, is occasioned by the presence of an essential oil. This may be removed by adding a little sweet or almond oil, and then violently stirring the wine for some time. The fixed oil attracts and seizes on the essential oil, and rises with it to the surface, when it is easily skimmed off, or the liquid under it drawn off. A few slices of burnt or toasted bread, or a little bruised mustard seed or coarsely powdered charcoal, will often have the same effect.

759. Pasteur's Method of Preserving Wines. M. Pasteur announced some time ago that wines became spoiled in consequence of the presence of microscopic organisms, which could be destroyed by exposing the wine, for a few moments only, to a temperature of 131° Fahr. A committee of experts was appointed to make a comparative examination of wines which had and which had not been subjected to heat; M. Lapparent being President, and M. Dumas and M. Pasteur assisting. They concluded that the preservation of wine in bottles is greatly improved by heating; that the destruction of the germs is perfect, without the least impairment of the taste, color, or limpidity of the wines.

760. To Determine the Nature of Acidity in Wine. If wine has undergone the acetous fermentation, then convert it at once into vinegar by one of the usual modes. But if its acidity proceeds from an excess of tartaric acid, this defect may be remedied by shaking the wine with a concentrated solution of neutral tartrate of potassa, which, with the surplus of tartaric acid, will form bitartrate of potassa, and precipitate as such. To discover the nature of the acidity, neutralize an ounce or so of the wine with some carbonate of soda, then add a small quantity of sulphuric acid, and boil up; if acetic acid or vinegar be present, it will be perceptible by its odor. (*See No.* 751.)

761. Parent's Method of Preserving Wine. This consists in the addition of a small quantity of tannin or tannic acid to the wine, which perhaps acts in a similar way, by destroying the vitality of the spores of the fungus, since a microscopic examination of wine known to contain these germs, within a few weeks after being treated with the tannin, has failed to detect the slightest trace. Indeed, wine which has already begun to change, and become turbid, can be restored to its primitive clearness, and with a great improvement in its taste. Care must be taken, however, to use only tannin which has been prepared from the constituents of the grape, since the slightest proportion of the extract of nut-gall, although accomplishing the general object of destroying the fungus, will impart a peculiar taste, which never disappears.

762. Antiferments. Substances used in small quantities for arresting fermentation in cider, wine, and malt liquors. The following formulæ are effective, and have the advantage of being harmless. (*See No.* 835.)

763. Antiferments for Cider. Sulphite (not sulphate) of lime in fine powder, and as newly prepared as possible. Or, 2 parts sulphite of lime and 3 parts ground black mustard seed.

764. Antiferments for Cider, Wine, Malt Liquors, &c. Grind or bruise together 13 pounds new mustard seed and 1 pound cloves. This mixture may be used with or without the addition of 10 ounces ground capsicum.

765. To Induce Fermentation. If fermentation does not begin within a reasonable time, raise the temperature by covering the vessel with blankets, and moving it near to a fire. Or, warm a portion of the must and add it to the rest. A small quantity of yeast, previously well mixed with some of the liquor, gently stirred in, will have the same effect. Or, the must may be warmed by placing large stone bottles, filled with boiling water and well corked, in the liquor.

766. To Arrest Fermentation. Dip a strip of linen or cotton, an inch wide and seven inches long, into melted sulphur. Fasten a wire into the bung of a 60-gallon cask, so that the end will hang about the middle of the inside of the cask, bend the end up to form a hook, place the sulphur tape on the hook, ignite it, and insert it in the cask, bunging loosely. In about an hour the cask will be impregnated with sulphurous acid; then withdraw the match, and fill up with wine, and bung up tight. This will stop further fermentation. This is a good plan for white wines, but not for red wines, as sulphur injures their color. Sulphite (not sulphate) of lime is also sometimes employed to arrest fermentation. (*See No.* 835.)

Cordials or Liqueurs.

The materials employed in the preparation of cordials are rain or distilled water, white sugar, and clean, perfectly flavorless spirit. To these may be added the substances from which the flavor and aroma are extracted, which distinguish and give character to the particular cordial to be made, and also the articles employed as "finings" when artificial clarification is had recourse to. In the preparation or compounding of cordials, one of the first objects which engages the operator's attention is the production of an alcoholic solution of the aromatic principles which are to give them their peculiar aroma and flavor. (*See No.* 812.) This is done either by simple infusion or maceration, or by maceration and subsequent distillation, or by flavoring the spirit with essential oils. In the preparation of liqueurs, glycerine has been found to be admirably adapted for preserving the characteristic flavors of those compounds, and it has consequently become the great favorite of this class of manufactures. (*See No.* 725.)

768. Cordials Made by Maceration, or with Essential Oils. When essential oils are employed to convey the flavor, they are first dissolved in a little of the strongest rectified spirit of wine, and when added to the spirit they are mixed up with the whole mass as rapidly and as perfectly as possible by laborious and long continued agitation. The stronger spirit may be reduced to the desired strength by means of clear soft water, or the clarified syrup used for sweetening. The sugar employed should be of the finest quality, and is preferably made into syrup before adding it to the aromatized spirit; and this should not be added until the latter has been rendered perfectly fine by filtering or fining. Some spirits, as anise seed, etc., frequently require this treatment, which is best performed by running them through a fine and clean filter, having previously mixed them with a spoonful or two of magnesia. By good management, cordials thus made will be perfectly clear and transparent; but should this not be the case, they may be fined with the whites of about 12 or 20 eggs to the hogshead, or by adding a little alum, either alone or followed by a little carbonate of soda or potassa, both dissolved in water. In a week or a fortnight the liquor will be clear.

769. To Make Doppelt Kummel or Caraway. Dissolve separately, each in a little 95 per cent. alcohol, ½ drachm oil of anise, and 5 drops each of the oils of calamus, bitter almonds, and coriander; dissolve also 1 to 1½ ounces oil of caraway in sufficient alcohol (95 per cent.) to make a clear solution. Incorporate these with 40 gallons French proof spirit; and add 10 pounds sugar dissolved in 5 gallons water.

770. To Make Anisette. To 30 gallons French proof spirit add 4 ounces essence of star anise dissolved in 95 per cent. alcohol, and 105 gallons syrup of 10° Baumé. Stir for ½ an hour, settle and filter.

771. To Make Curaçoa. Slice the outside peel very thin from 60 bitter oranges; infuse for 15 days with 4 drachms bruised cinnamon, and 2 drachms bruised mace, in 5 gallons 95 per cent. French spirit, stirring every day. Then add 25 pounds white sugar dissolved in 2 gallons water; color with caramel (*see No.* 694); stir thoroughly, and filter.

772. To Make Maraschino. Dissolve in 1¼ gallons 95 per cent. alcohol, 1½ ounces essence of maraschino, 1½ drachms essence of rose, ½ drachm essence of noyau, 5 drops essence of cloves, and 8 drops essence of cinnamon; add ½ gallon orris root flavoring. (*See No.* 669.) Mix the above with 12 gallons 95 per cent. alcohol and 26 gallons syrup of 30° Baumé. Stir thoroughly and filter.

773. Superfine Maraschino. 4 ounces essence of noyau; 1 ounce essence of rose; ½ ounce essence of neroli (genuine); 4 drachms of mace, infused in 95 per cent. alcohol; ½ pound cinnamon, infused in 1 quart of water; 2 ounces cloves, infused in 1 pint of water; 2 pounds orris root (powdered), infused in 2 gallons 95 per cent. alcohol for 15 days. Dissolve the essences in 2 gallons 95 per cent. alcohol. Mix, put into a barrel 41 gallons 85 per cent. alcohol; add the aromas, in 4 gallons 95 per cent. alcohol; sugar syrup, 90 gallons 32° Baumé. Stir all the ingredients well together for at least half an hour, and let the mixture stand two weeks; then filter and put in the filter two or three sheets of filtering paper. (*See No.* 811.)

774. Maraschino. 1½ ounces essence of maraschino, 1½ drachms essence of rose, ½ drachm essence of noyau, 8 drops essence of cinnamon, 5 drops essence of cloves, ½ pound orris root (powdered), infused in ½ gallon 95 per cent. alcohol for 15 days. Dissolve the essences in 1 gallon 95 per cent. alcohol. Mix, put in a barrel 12 gallons 80 per cent. alcohol and add 2 gallons 95 per cent. perfumed alcohol (as described above); sugar syrup, 26 gallons 25° Baumé's saccharometer. Mix and filter as directed in the last receipt.

775. Maraschino. 3½ ounces essence of noyau, 6 drachms essence of rose. Dissolve the above in ½ gallon 95 per cent. alcohol, and add 4 spoonfuls of magnesia, 1 gallon orange flower water, ½ pound cinnamon (bruised) infused in ½ gallon water, ½ pound cloves (bruised), infused in ½ gallon of water, 4 drachms mace infused in alcohol, 2 pounds orris root (powdered) infused in 2 gallons 95 per cent. alcohol for 15 days. Mix 41 gallons 80 per cent. alcohol, 90 gallons syrup 25 degrees Baumé, and add 4 gallons perfumed spirits, as described above. Stir and filter as already directed.

776. Curaçoa d'Hollande. 2 pounds Curaçoa orange peel, ½ pound Ceylon cinnamon. Let them soak in water; boil them for 5 minutes with the juice of 32 oranges and 14 gallons of white plain syrup; then add 6 gallons of 95 per cent. alcohol; strain, filter; color dark yellow with sugar coloring. This receipt will make a splendid curaçoa.

777. Curaçao. 2 ounces each essence of bitter oranges and neroli; ½ ounce essence of cinnamon; 3 drachms mace infused in alcohol. Dissolve the above essences in 1 gallon 95 per cent. alcohol, then put in a clean barrel 13 gallons 85 per cent. alcohol, 26 gallons sugar syrup 30 degrees Baumé, and add 1 gallon perfumed spirit, as above. Color with saffron or turmeric.

778. Champion Anisette. Put into a barrel 30 gallons 85 per cent. alcohol. Add 4 ounces essence of anise seed, which dissolve in 2 gallons 95 per cent. alcohol. Add 103 gallons sugar syrup 10° Baumé. Stir 15 minutes and let it rest 4 or 5 days, then filter. Add 2 or 3 sheets of filtering paper. (*See No.* 811.)

779. Anisette. Put in a barrel 13 gallons 95 per cent. alcohol. Dissolve 3½ ounces essence of green anise seed in 1 gallon 95 per cent. alcohol, and add ½ gallon orange flower water, 8 or 10 drops infusion of mace, and 5 drops essence of cinnamon. Then put in the barrel 26 gallons sugar syrup 25° Baumé. Stir and filter as directed in the last receipt.

780. Anise Seed Cordial. Dissolve 3 drachms of oil of anise seed in 2½ gallons of 95 per cent. alcohol; then add 2½ gallons of fine white syrup, mixed with 4½ gallons of water. Stir and filter.

781. Malliorca d'Espagne. 40 gallons 55 per cent. alcohol, 5 ounces essence green anise seed and 5 ounces essence of star seed dissolved in 95 per cent. alcohol, ½ drachm ether (to give the cordial age). Stir and filter.

782. Blackberry Brandy. To 10 gallons blackberry juice, and 25 gallons spirits 40 above proof, add 1 drachm each of oil of cloves and oil of cinnamon dissolved in 95 per cent. alcohol, and 12 pounds white sugar dissolved in 6 gallons water. Dissolve the oils separately in ½ pint 95 per cent. alcohol; mix both together, and use one half the quantity; if the cordial is not sufficiently flavored, use the balance.

783. Blackberry Brandy. ½ ounce each of cinnamon, cloves, and mace, 1 drachm cardamom. Grind to a coarse powder; add to 16 pounds of blackberries, mashed, and 5 gallons of 95 per cent. alcohol. Macerate for two weeks; press it; then add 10 pounds of sugar, dissolved in 3½ gallons of water. Filter.

784. Cherry Brandy. Mash 16 pounds of black cherries with their stones; 5 gallons 95 per cent. alcohol. Macerate for two weeks; press it; then add 10 pounds of sugar, dissolved in 3½ gallons of water. Filter.

785. Peach Brandy. Mash 18 pounds of peaches, with their stones; macerate them for 24 hours with 4½ gallons of 95 per cent. alcohol and 4 gallons water. Strain, press, and filter; add 5 pints white plain syrup. Color dark yellow with burnt sugar coloring.

786. Imperial Peach Brandy. Take 4½ ounces powdered bitter almonds, 3½ gallons of 95 per cent. alcohol, 5½ gallons of water. Mix together, and macerate for 24 hours; then add a strained syrup, made of 3½ pounds of sugar, 1 pint of peach jelly, 2½ ounces preserved ginger, 1 lemon cut in slices, 1 drachm of grated nutmegs, 1 drachm of allspice in powder, and 5 pints of water boiled for 2 minutes. Mix the whole, and filter.

787. Peppermint Brandy. To 40 gallons proof spirit add 4 ounces essence of peppermint, dissolved in 95 per cent. alcohol. Color with ½ pound powder of turmeric infused in 1 gallon spirit 95 per cent. Use this infusion in such quantity as to get the proper shade.

788. Kirschenwasser. 100 gallons proof alcohol, 5 ounces essence of noyau, 2 drachms essence of rose. Dissolve the latter ingredient in some 95 per cent. alcohol and add a spoonful of magnesia, 2 pounds orris root (powdered), infused 15 days in 2 gallons 95 per cent. alcohol, 1½ gallons sugar syrup. Stir, and filter if necessary.

789. Caraway Cordial. Dissolve 6 drachms oil of caraway in 3 gallons 95 per cent. alcohol; add a syrup made of 42 pounds of sugar and 4½ gallons of water. Filter.

790. Ratafia. This word is derived from the Latin pax ratafiat (let peace be ratified). The Latins used to drink ratafia on signing their treaties of peace. Ratafia may be made with the juice of any fruit. Take 3 gallons cherry juice, 4 pounds sugar, dissolved in the cherry juice. Steep in 2½ gallons brandy 10 days 2 drachms cinnamon, 24 cloves, 13 ounces peach leaves, 8 ounces bruised cherry kernels. Filter; mix both liquors, and filter again.

791. To Prepare Cherry Juice by Infusion for making Cherry Bounce and Brandy. Put the cherries into barrels and cover them with 95 per cent. spirit; let them steep for 1 month, and stir them well every 8 days. Use the juice that runs off first, and repeat this operation 2 or 3 times. The last time, you may bruise the cherries and stones, and steep them all together to make cherry brandy.

792. To Prepare Cherry Juice for Boiling. Put the cherries in a kettle tinned inside, cover them with water, and boil them at a gentle heat for 1 hour. When cold put them into barrels and add 1 gallon 95 per cent. spirit to each 10 gallons of the juice.

793. To Make Cherry Bounce (Superfine). To 15 gallons cherry juice, add 15 gallons 80 per cent. spirit; 30 gallons Catalonia or Marseilles wine; 1½ ounces essence of noyau; 3 ounces mace infused in 1 quart 95 per cent. alcohol; ½ pound cinnamon infused in ½ gallon water; ½ pound cloves ground and infused in 1 quart of water. Put all the above ingredients in a clean barrel and add 60 gallons sugar syrup 25° Baumé. Stir up the ingredients well, and filter after 4 or 5 days. If the color is not deep enough add a little sugar coloring. The above receipt is to make 120 gallons, but a much smaller quantity may be made by reducing the quantity of each ingredient and observing the same proportion in all.

794. To make Cherry Bounce (Second Quality). To 12 gallons cherry juice, add 30 gallons 80 per cent. spirit; 30 gallons Catalonia or Marseilles wine; 3 ounces essence of noyau; ½ pound cinnamon ground and infused in ½ gallon water; ½ pound cloves ground and infused in ½ gallon water; 1½ ounce mace infused in 1 pint 95 per cent. alcohol. Mix all the above ingredients in a clean barrel, and add 60 gallons sugar syrup 13° Baumé. Stir up all the ingredients well together, and filter after 4 or 5 days. Make the color a little darker with sugar coloring (*see No.* 694), and to give a good shade add a little archil.

795. To Make Guignolet, or French Cherry Bounce. To 20 gallons cherry juice add 7½ gallons 95 per cent. spirit; 7½ gallons Catalonia or Marseilles wine; ¾ ounce powdered orris root (infused in 1¼ gallons 95 per cent. alcohol); ½ gallon cinnamon water (made as in last receipt); ½ gallon clove water (made as in last receipt); 1½ ounces mace infused in 95 per cent. alcohol. Mix all the above ingredients in a clean barrel, and add 68 gallons sugar syrup 25° Baumé. Stir up the mixture and let it rest 8 days; then strain.

796. Cordials by Distillation. The solid ingredients should be coarsely pounded or bruised before digestion in the spirit, and this should be done immediately before putting them into the cask or vat; as, after they are bruised, they rapidly lose their aromatic properties by exposure to the air. The practice of drying the ingredients before pounding them, adopted by some workmen for the mere sake of lessening the labor, cannot be too much avoided, as the least exposure to heat tends to lessen their aromatic properties, which are very volatile. The length of time the ingredients should be digested in the spirit should never be less than 3 or 4 days, but a longer period is preferable when distillation is not employed. In either case the time allowed for digestion may be advantageously extended to 10 or 15 days, and frequent agitation should be had recourse to. In managing the still, the fire should be proportioned to the ponderosity of the oil or flavoring, and the receiver should be changed before the faints come over, as the latter are unfit to be mixed with the cordial. The stronger spirit may be reduced to the desired strength by means of clear soft water, or the clarified syrup used for sweetening.

797. To Make Absinthe by Distillation. Put the following ingredients into a cask:—1½ pounds large absinthe, 2 pounds small absinthe, 2½ pounds long fennel, 2½ pounds star anise (breaking the star only), 2½ pounds green anise seed, 6 ounces coriander seed, and 1 pound hyssop; moisten the whole with a little water, allowing it time to soften and swell; then add 12 gallons 95 per cent. alcohol, and steep for 2 or 3 days; next add 10 gallons water, and let the whole steep for 1 day more. The water will reduce the alcohol to about 23 gallons of proof spirit. Distill it, and it will produce nearly 15 gallons absinthe of 65 to 70 per cent. strength. Change the receiver as soon as the spirit, as it comes from the worm, begins to assume a reddish tinge. Color the distilled product, by steeping in it for 10 or 15 days ¾ pound mint leaves, ½ pound melissa leaves, ½ pound small absinthe, 2 ounces citron peel, and ½ pound bruised liquorice root. Strain and filter.

798. Absinthe by Distillation. This is made in the same manner as in the former receipt, with the following ingredients:—40 gallons 75 per cent. spirits, 20 pounds fennel, 20 pounds green anise, 16 pounds large absinthe, 1 pound coriander, and 20 gallons water. This is colored, after distillation, by adding 4 pounds small absinthe, and heating it again until as hot as the hand can bear; then extinguish the fire, let it cool, settle, and filter it.

799. Superfine Curaçoa. Charge of the still: 35 pounds green orange peel, or 50 pounds yellow; 25 gallons 95 per cent. alcohol; add 4 gallons water, making in all 29 gallons, at 90 per cent. Digest for 10 days, and stir daily. In making the above, the following directions must be carefully observed:—I. Distill very carefully. II. When you have drawn off 20 gallons, add 10 gallons water, to draw off the faints, which may be distilled again in the next distillation. III. To make superfine Curaçoa, distill over again in a water-bath, adding 5 gallons water. IV. To know when the faints are coming off, take a little in a glass as it flows, and add ¾ water, as if for absinthe. When it no longer turns milky, the faints are coming off; reserve them for the next distillation. Reduce the Curaçoa above distilled to 82 per cent. Tralle's, which will give 26 gallons. Add 12 gallons 82 per cent. spirit, 7 gallons coloring (as given below), 90 gallons syrup 31° Baumé.

800. Coloring for Curaçoa. 3½ pounds Brazil wood; 1½ pounds each Campeachy and yellow wood, 7 gallons 90 per cent. alcohol. Mix the above and heat in a water-bath, putting on the head. When the head begins to get hot, rake out the fire and let the whole cool together in the bath.

801. Superfine Maraschino. Charge of the still with water-bath: Take 70 pounds peach or apricot stones, wash with tepid water, and put them into a barrel, making a square hole 4 or 5 inches, in the head, for that purpose. Cover them with 35 gallons 95 per cent. alcohol, and let them steep for one month. Then distill the whole.

Note the following observations.—I. Before distilling, add 4 pounds of peach flowers. II. Keep the fire at the same degree of heat, or the Maraschino will have an oily taste. III. When nearly finished, add 10 gallons water, to draw off the faints, which will do for another distillation. Reduce the spirit above distilled to 82 per cent. and you will get 45 gallons. If you have not that quantity, add spirit of the same strength to make it up. Then add 90 gallons sugar syrup 32° Baumé. When you have not used peach flowers in the distillation, take 2 pounds orris root powder, and steep it in 2 gallons alcohol 95 per cent. for 15 days; then filter, and add it to the mixing, not to the distillation.

802. Boitard's Anisette. Charge of the still, water-bath: 20 pounds green anise (washed in river water), 3 pounds star anise (being careful to break the stars only), 1 pound coriander seed (bruised), 40 gallons 95 per cent. alcohol. Put the above into the water-bath with 4 gallons water, and distill. After distilling 35 gallons, add 10 gallons of water to bring off the faints, which may be distilled again. The first 5 gallons of faints may be added to the distilled spirit, which will give 40 gallons aromatized alcohol. Reduce this to 80 per cent. by adding, say 5 gallons distilled water, and then add 90 gallons fine white sugar syrup, 31° Baumé. This will give 135 gallons fine anisette.

803. Chauvet's Anisette. Charge of the still, water-bath: 20 pounds green anise, 1¼ pounds coriander seed, 2 drachms neroli, 7½ pounds star anise (break the stars only), 1¼ pounds orris root powdered, 40 gallons 95 per cent. alcohol. Treat precisely as in the last receipt. Reduce the perfumed alcohol to 82 per cent. by adding 4 gallons water, and further add 1½ gallons double orange flower water, and 90 gallons white syrup 31° Baumé. Stir well and let it rest 5 to 8 days, then filter through blotting paper. This will give 135 gallons superfine anisette.

804. Marasquino di Zara. Charge of the still, water-bath: 18 pounds raspberries, 6 pounds orange flowers, 12 pounds sour red cherries (Morello). Mash the whole to a pulp with stones, macerate 24 hours with 7 gallons 95 per cent. alcohol and 7 gallons of water. Distill from off the water, 6 gallons flavored alcohol, and add 14 gallons of the whitest plain syrup about 34° Baumé.

805. Malliorca d'Espagne. Charge of the still, water-bath: 40 gallons 55 per cent. alcohol, 18 pounds green anise seed, 5 gallons river water. Put into the water-bath only 20 gallons of the alcohol, and 5 gallons river water. When 18 gallons are distilled off, add the remaining 20 gallons of alcohol, and continue the distillation until 18 gallons more are obtained, which mix with the 18 gallons previously obtained, and add one drachm of ether to give it age.

806. Elixir Vegetal de la Grande Chartreuse. Macerate 640 parts by weight, each, of the fresh herb of sweet balm and hyssop, 320 parts of fresh root of angelica, 160 of cannella, and 40 each of Spanish saffron and mace, in 10,000 parts of alcohol, for eight days. Then distill it onto a certain quantity (which varies according to the color desired) of fresh balm and hyssop; after a time these are expressed, the liquor sweetened with 1250 parts of sugar, and filtered.

807. Fining with Isinglass for Cordials. Take half an ounce of the best isinglass, and dissolve it over a gentle fire, in a pint of water slightly seasoned with good vinegar, or three tea-spoonfuls of lemon juice. Beat it from time to time, adding a little of the seasoned water. When you obtain a complete solution, gradually add the foaming liquid to the cordial, stirring all the while. Then stir for 15 minutes after it is all added, and let it rest for 3 days; by that time the cordial will be bright and clear. The above quantity is sufficient to clarify 25 gallons of cordial.

808. Fining with Eggs for Cordials. Take the whites of 4 eggs, beat them to a stiff froth, add a little alcohol, and mix it gradually with 20 gallons of cordial, stirring all the while, and it will soon clarify the liquor.

809. Fining with Potash for Cordials. 2 ounces of carbonate of potash (salts of tartar), dissolved in a quart of water, is sufficient to settle 20 gallons of cordial; add and stir as directed above.

810. Fining with Alum for Cordials. 6 drachms of powdered calcinated alum, dissolved in alcohol, is sufficient to clarify 20 gallons of cordial; add as directed above.

811. Filter Bags for Cordials. The filter bags used for rendering cordials transparent are made of flannel, felt, Canton flannel, and other materials, according to the thickness or density of the liquor, and are generally of a conical shape. In order to perform the operation of filtering cordials thoroughly, it is necessary that there should be placed inside of each bag 1 or 2 sheets of filtering paper prepared as follows: Rub each sheet of paper until it becomes soft and flimsy, like a piece of cloth, then tear it in small pieces and place it in a pail, pour over it a little boiling water, and rub and beat it up until it becomes a soft pulp; afterwards add more water, and continue the same as if you were beating up eggs. When the pulp assumes the appearance of a fine paste, fill up the pail with water and throw the contents into the filter; as soon as the water has run through, fill up the filter again so as to keep it full. When the liquid runs clear and limpid let it all run through, and commence filtering the cordial, being careful to keep the filter always full. If the liquor does not run clear, add about 2 ounces of granulated animal charcoal (sifted and fanned from the dust) to each filter. The charcoal should be washed with a little muriatic acid before being used.

812. The Aroma of Cordials. It requires a great deal of experience to combine different perfumes to produce any certain required aroma, a knowledge is necessary of the effect produced by perfumes in combination. The mere facts laid down in receipts will not be sufficient for a liquor manufacturer; he must know just what, and how much of it to use, to counteract what is objectionable, and produce or increase the correct aroma. He will frequently find that a single aromatic perfume fails to give the effect he anticipated; and yet the addition of a mere atom of some other perfume may be all that is required. Thus, the flavor of star-anise is accompanied by a slight, but objectionable odor of bed-bugs; a very small addition of green anise and fennel counteracts this. Ambergris, alone, gives scarcely any perfume, but musk brings it out. The quince has a peculiar taste which is corrected by cloves; the after-taste of cinnamon is also destroyed by cloves; vanilla has more flavor if pounded with sugar than when ground with it. Absinthe requires the zest of the lemon to take away its naturally bitter taste. These examples will show that considerable experience is needed to be able to blend perfumes with any degree of success. (*See No.* 767.)

813. Imitation Peach Brandy. Take ½ gallon honey dissolved in water; 3½ gallons alcohol; ½ gallon Jamaica rum; 1 ounce catechu, bruised to a paste; 1 ounce acetic ether. Add water to make 10 gallons, flavored with 4 ounces of bitter almonds. No coloring required.

Cider.

To make good cider the apples should be allowed to hang on the tree as long as the wind and frosty nights will let them. The riper they are, the better the cider. They are picked up and placed in a large heap, either in the orchard or at the cider mill, and are allowed to lie a few days to complete the ripening process, in which the starch is converted into sugar, and if any are found bruised or rotten, put them in a heap by themselves, for an inferior cider to make vinegar. They are then rasped or ground into pulp. If the weather is cool and the apples are not quite ripe, it is better to let the pulp remain in the vat a few days before pressing out the juice. This gives the cider a higher color, makes it sweeter, and of better flavor.

833. To Press the Apples. The process of pressing is simple, but requires some skill. 4 boards about 6 inches wide are nailed together in a square, the size it is desired to make the cheese, say from 4 to 5 feet. This is placed on the bottom of the press, and a little clean rye or wheat straw, pulled out straight into bundles, is put inside, with the ends extending about a foot all around. The pulp is then put into this rim, forming a layer about 6 inches thick; the straw is then turned on it, and a little pulp placed on the straw to keep it down. The rim is then lifted and a stick is placed at each corner on the layer of pulp added, and the straw turned over it as before. This process is repeated until the cheese is as large as desired, using say from 75 to 100 bushels of apples. When they can be obtained use hair cloths instead of straw, to place between the layers of pomace. The straw, when heated, gives a disagreeable taste to the cider.

834. Sweet or Unfermented Cider. The cider will commence to flow at once, and it is better to let the cheese settle down somewhat before turning the screw. If pressed too much at first, the pulp may burst out at the sides. As the cider runs from the press, let it pass through a hair-sieve into a large open vessel, that will hold as much juice as can be expressed in one day. The cheese is generally allowed to remain under the press all night, and before leaving it in the evening, the screw is turned as tight as possible. In the morning additional pressure is given, and when the cider has ceased to flow, the screw is turned back, the boards taken off, and the corners of the cheese are cut off with a hay knife and the pomace laid on the top. The pressure is again applied, and the cider will flow freely. As soon as it ceases, remove the pressure and cut off 4 or 5 inches of pomace from the sides of the cheese, place it on top, and apply the pressure again as long as any cider will flow. 8 bushels of good apples will make a barrel of cider. In a day, or sometimes less, the pomace will rise to the top, and in a short time grow very thick; when little white bubbles break through it, draw off the liquor by a spigot placed about 3 inches from the bottom, so that the lees may be left quietly behind. The cider is usually put in barrels at once, and sold while sweet.

835. To Preserve Cider. Strictly speaking, we suppose the sweet juice of the apple is not cider, any more than the sweet juice of the grape is wine. It is converted into cider by fermentation. Those who prefer sweet cider resort to various methods for arresting this process, such as putting a handful of powdered clay into each barrel, or 2 or 3 pounds of well burned charcoal. Others add a little mustard seed, about a gill of seed to each barrel. Sometimes a few gallons of cider are placed in the barrel, and then a rag dipped in brimstone is attached to a long tapering bung; this is ignited and the bung loosely inserted. After the brimstone is consumed, the barrel is rolled until the cider has absorbed the sulphurous acid gas. The barrel is then filled up with cider. The sulphurous acid gas acting on the albuminous matter in the cider arrests fermentation. The objection to this method is that, if too much gas is absorbed, it may prove unpleasant, if not injurious. To obviate this, sulphite of lime is now used, which has the property of checking fermentation, making the cider perfectly clear, and imparting an agreeable taste. We have tasted cider preserved in this way that was excellent, and we have also tasted some that was execrable; but this may have been more the fault of the material than of the method. When the cider in the barrel is in a lively fermentation, add as much white sugar as will be equal to ¼ or ½ pound to each gallon of cider (according as the apples are sweet or sour), let the fermentation proceed until the liquid has the taste to suit, then add ½ ounce of sulphite (not sulphate) of lime to each gallon of cider; shake well, and let it stand 3 days, and bottle for use. The sulphite should first be dissolved in a quart or so of cider before introducing it into the barrel of cider. Agitate briskly and thoroughly for a few moments, and then let the cider settle. The fermentation will cease at once. When, after a few days, the cider has become clear, draw off and bottle carefully, or remove the sediment and return to the original vessel. If loosely corked, or kept in a barrel on draught, it will retain its taste as a still cider. If preserved in bottles carefully corked, which is better, it will become a sparkling cider, and may be kept indefinitely long. (*See Nos.* 762 *&c.*) Some think that cider, when treated by this method, is liable to induce cramps and loss of appetite, but we have never experienced any such unpleasant results from its use. Another plan, which, however, we have not tried, but is strongly recommended, is to mix 1 pint of hard-wood ashes (hickory is best) and 1 pint fresh slaked lime with 1 quart of new milk; this mixture is to be stirred into each open barrel of cider; after remaining quiet for about 10 hours the pomace will rise to the surface, and may be skimmed off; the clear cider can be drawn off by means of a faucet inserted near the bottom of the barrel; it is advisable to strain it as it is drawn off, to separate any hardened pomace that may remain in it. (*See Nos.* 852 *and* 853.) Whatever method be adopted, the cider must be drawn off into very clean, sweet casks, and closely watched. The moment white bubbles are perceived rising at the bung-hole, rack it again. When the fermentation is completely at an end, fill up the cask with cider in all respects like that already contained in it, and bung it up tight. The most perfect plan for excluding all action of the air from the surface of the cider, and preserving it sweet, is the addition of a tumbler of sweet oil before finally closing the bung-hole. It is not an easy matter to keep cider sweet and pure for any length of time, especially if the weather is warm. If the cider is not made until just before winter sets in, and can afterwards be kept at or near the freezing point, it will remain sweet and excellent.

836. Rules for Making Good Pure Cider. Always choose perfectly ripe and sound fruit.

Pick the apples from the tree by hand. Apples that have been on the ground any length of time contract an earthy flavor, which will always be found in the cider.

After sweating, and before being ground, wipe them dry, and if any are found bruised or rotten, put them in a heap by themselves, from which to make an inferior cider for vinegar.

As fast as the apples are ground, the pomace should be placed in a previously prepared open vat, of suitable size, and with a false bottom, strainer, or clean straw about it. Let the pomace remain about one day, then draw off, return the first, and continue to do so until it runs clear. Let the juice percolate or filter for one or more days. The cider thus extracted will compare closely with any clear, rich syrup, and is alone deserving the name of temperance cider, and may be drank, or used for many purposes, as a choice and superior article. In this way, about one-third of the cider will separate; the balance may then be expressed by the use of the press.

To press out the juice, use a clean strainer cloth inside the curb, with some clean straw intermixed in thin layers with the pomace, and apply the power moderately.

As the cider runs from the vat or press, place it in a clean, sweet cask or open tub, which should be closely watched, and as soon as the little bubbles commence to rise at the bung-hole or top, it should be racked off by a spigot or faucet placed about 2 inches from the bottom, so that the lees or sediment may be left quietly behind.

The vinous fermentation will commence sooner or later, depending chiefly upon the temperature of the apartment where the cider is kept; in most cases, during the first 3 or 4 days. If the fermentation begins early and proceeds rapidly, the liquor must be racked or drawn off and put into fresh casks in 1 or 2 days; but if this does not take place at an early period, but proceeds slowly, three or four days may elapse before it is racked. In general, it is necessary to rack the liquor at least twice. If, notwithstanding, the fermentation continues briskly, the racking must be repeated, otherwise the vinous fermentation, by proceeding too far, may terminate in acetous fermentation, when vinegar will be the result.

In racking off the liquor, it is necessary to keep it free from sediment, and the scum or yeast produced by the fermentation. When the fermentation is completely at an end, fill up the cask with cider in all respects like that contained in it, and bung it up tight, previous to which a tumbler of sweet oil may be poured into the bung-hole, which will exclude the oxygen and prevent the oxidation of the surface of the wine.

Sound, well made cider, that has been produced as above directed, and without any foreign mixtures, is a pleasant, cooling and wholesome beverage; while, on the contrary, the acids and drugs added to already impure liquor, retard fermentation, thus adding poison to poison, producing colic, and not unfrequently incurable obstructions.

837. To Make Good Fermented Cider. To make good fermented cider that will keep a year or more without turning too sour to be used for anything but vinegar, is not a difficult matter. The first thing is to exclude all decayed fruit, but it should be quite ripe. Not a drop of water should be used in the process of manufacture. The sweeter the juice, the stronger the cider, and the better it will keep. Put the barrel immediately in a cool cellar—the cooler the better. The fermentation may go on slowly or rapidly, practice differing in this respect. In the former case the liquid is treated in all respects like wine. The cask has a bung in which is fixed, air-tight, a tin tube bent at right angles, or a piece of india-rubber tube. The free end of the tube in either case dips into a vessel of water. This arrangement allows the gases liberated in fermentation to pass out, and the end of the tube being covered with water, air cannot pass in. The bubbling of the gas through the water shows how the fermentation is progressing. When this has ceased, the cider is racked off into clean casks, which are to be full and bunged tightly. Much of the excellence of cider depends upon the temperature at which the fermentation is conducted; a point utterly overlooked by the manufacturers of this liquor. Instead of the apple juice, as soon as it is expressed from the fruit, being placed in a cool situation, where the temperature should not exceed 50° or 52° Fahr., it is frequently left exposed to the full heat of autumn. In this way much of the alcohol formed by the decomposition of the sugar is converted into vinegar, by the absorption of atmospheric oxygen, and thus the liquor acquires that peculiar and unwholesome acidity known as "hardness" or "roughness." When, on the contrary, the fermentation is conducted at a low temperature, nearly the whole of the sugar is converted into alcohol, and this remains in the liquor, instead of undergoing the process of acetification.

838. To Make Fine Cider by Another Process. After obtaining the juice as already directed *(see No. 836)*, strain it through a coarse hair-sieve into open vats or close casks. When the liquor has undergone the proper fermentation in these close vessels, which may be best effected in a temperature of from 40° to 55° Fahr., and which may be known by its appearing tolerably clear, and having a vinous sharpness upon the tongue, any further fermentation must be stopped by racking off the pure part into open vessels, exposed for a day or two in a cool situation. After this the liquor must again be put into casks and kept in a cool place during winter. The proper time for racking may always be known by the brightness of the liquor, the discharge of the fixed air, and the appearance of a thick crust formed of fragments of the reduced pulp. The liquor should always be racked off anew, as often as a hissing noise is heard, or as it extinguishes a lighted match held to the bung-hole. When a favorable vinous fermentation has been obtained, nothing more is required than to fill up the vessels every two or three weeks, to supply the waste by fermentation. By the beginning of March the liquor will be bright and pure, and fit for final racking, which should be done in fair weather. When the bottles are filled, they should be set by, uncorked, till morning, when the corks must be driven in tightly, secured by wire or twine and melted resin, or any similar substance.

839. To Prepare Casks for Cider. Cider should never be put into new casks without previously scalding them with water containing salt, or with water in which pomace has been boiled. Beer casks should never be used for cider, or cider casks for beer. Wine and brandy casks will keep cider well, if the tartar adhering to their sides is first carefully scraped off and the casks be well scalded. Burning a little sulphur in a cask will effectually remove must.

840. Canned Cider. Cider may be preserved sweet for years, by putting it up in air-tight cans after the manner of preserving fruit. The cider should be first settled and racked off from the dregs, but fermentation should not be allowed to commence before canning.

841. To Cleanse Cider Barrels. Take lime water and a trace chain and put them in the barrel through the bung-hole, first securing a strong twine to the chain to draw it out with. Then shake the barrel about until the chain wears or scours off all mould or pomace remaining in the barrel. Then rinse well with water; after throwing out the rinsing water put in a little whiskey, turning the barrel to bring it in contact with every part, and pour out all you can.

842. To Clarify and Improve Cider. Cider should be stored in a cool place, and should not be drunk before it becomes sufficiently matured. To improve the flavor of a hogshead of cider, 1½ gallons of good brandy or rum are frequently added, with 2 ounces powdered catechu (dissolved in water), 7 pounds good moist sugar or honey, ½ ounce each bitter almonds and cloves, and 4 ounces mustard seed. These must be well stirred in, and occasionally stirred up for a fortnight, after which it must be allowed to repose for 3 or 4 months, when it will usually be found as bright as wine. Should this not be the case it must be fined with a pint of isinglass finings, or a dozen eggs, and in 2 weeks more it will be fit for use. If the cider be preferred pale, omit the catechu, and instead of the isinglass, fine with 1 quart of skimmed milk. If wanted of a light reddish or rose tint, use ¼ ounce cochineal, and omit the catechu.

843. To Bottle Cider. Preparatory to bottling cider it should be examined to see whether it is clear and sparkling; if not, it should be clarified again, and left for two weeks. The night before it is intended to be put into bottles, the bung should be left out of the cask, and left so until the next day, when it may be bottled, but not corked down until the day after, as, if this be done at once, many of the bottles will burst by keeping. The best corks and champagne bottles should be used, and it is usual to wire and cover the corks with tin-foil, after the manner of champagne. A few bottles may be kept in a warm place to ripen, or a small piece of lump sugar may be put into each bottle before corking, if wanted for immediate use, or for consumption during the cooler portion of the year; but for warm weather and for long keeping this is inadmissable. The bottled stock should be stored in a cool cellar, where the quality will be greatly improved by age.

844. Champagne Cider. Good cider, pale, 1 hogshead; spirit, 3 gallons; honey or sugar, 20 pounds. Mix and let them rest for 2 weeks, then fine with skimmed milk, ½ gallon. This will be very pale; and a similar article, when bottled in champagne bottles, and silvered and labeled, has been often sold to the ignorant for champagne. It opens very brisk if managed properly.

845. Fine Champagne Cider is made as follows:—To 100 gallons of good cider put 3 gallons of strained honey, or 24 pounds of good white sugar. Stir well and set it aside for a week. Clarify the cider with half a gallon of skimmed milk, or ¼ pound of dissolved isinglass, and add 4 gallons of pure spirits. After 2 or 3 days bottle the clear cider, and it will become sparkling. In order to produce a slow fermentation, the casks containing the fermenting liquor must be bunged up tight. It is a great object to retain much of the carbonic gas in the cider, so as to develop itself after being bottled.

846. Champagne Cider. (Another receipt.) 10 gallons of cider, old and clear. Put it in a strong iron-bound cask, pitched inside (like beer-casks); add 2½ pints clarified white plain syrup; then dissolve in it 5 ounces tartaric acid; keep the bung ready in hand, then add 7½ ounces of bicarbonate of potassa; bung it as quickly and as well as possible.

847. To Imitate Champagne Cider. Cider will resemble champagne if you put a tea-spoonful carbonate of soda, 2 tea-spoonfuls fine sugar, and a table-spoonful brandy in a tumbler, and fill it up with sharp cider.

848. How to Imitate Cider. A very fair imitation cider may be produced by using the following receipt:—25 gallons soft water; 2 pounds tartaric acid; 25 pounds New Orleans sugar; 1 pint yeast. Put all the ingredients into a clean cask and stir them up well after standing 24 hours with the bung out. Then bung the cask up tight, add 3 gallons spirits, and let it stand 48 hours, after which time it will be ready for use.

849. To Imitate Sweet Cider. Take water, 100 gallons; honey, 5 gallons; catechu powdered, 3 ounces; alum, 5 ounces; yeast, 2 pints. Ferment for 15 days in a warm place (in the sun if possible); then add bitter almonds, ¼ pound; cloves, ½ pound; burnt sugar, 2 pints; whiskey, 3 gallons. If acid be in excess, correct by adding honey or sugar. If too sweet, add sulphuric acid to suit the taste. We should prefer to add cider vinegar for acidulating when necessary.

850. Cheap Imitation Cider. Take water, 35 gallons; sulphuric acid, enough to make the water pleasantly sour; brown sugar, 50 pounds; alum, 4 ounces; ginger, 5 ounces; cloves, 5 ounces; bitter almonds, 6 ounces. Boil the last 4 ingredients in 2 gallons of the water for 2 hours, strain, and add this decoction to the other water. Burnt sugar may be added, to color, if wished. From 3 to 4 gallons of whiskey, if mixed with it, will give more body. It is generally known, we suppose, that bisulphite of lime may be advantageously employed in fresh cider to stop its conversion to vinegar. *(See No. 835.)*

851. Cheap-made Cider. Take of good cider and water, 1 hogshead each; molasses, 50 pounds; alum, dissolved, ½ pound. Brimstone matches to stop fermentation, by burning.

852. To Keep Cider Sweet. Allow the cider to work until it has reached the state most desirable to the taste, then add 1½ tumblers grated horseradish to each barrel, and shake up well. This arrests further fermentation. After remaining a few weeks, rack off and bung up closely in clean casks.

853. To Clear Cider. To clear and

improve cider generally, take 2 quarts of ground horseradish and 1 pound of thick gray filtering paper to the barrel, and either shake or stir until the paper has separated into small shreds, and let it stand for 24 hours, when the cider may be drawn off by means of a syphon or a stop-cock. Instead of paper, a preparation of wool may be taken, which is to be had in the market here, and which is preferable to paper, as it has simply to be washed with water, when it may be used again.

854. To Clean a Foul, Sour Cask, and Restore the Taste of the Wood. In order to accomplish this, dissolve about $1\frac{1}{2}$ pounds lime in 5 gallons boiling water. Rinse the cask to be restored with this liquid, and afterwards with boiling water. If the cask is very foul, it should also be rinsed with very dilute sulphuric acid after the lime water, and afterwards with boiling water. As a general thing, however, the lime water and boiling water are sufficient. To restore the natural taste of the wood, mash up in a mortar a handful of juniper berries and put them in the tainted cask, then pour over them several gallons boiling water, roll the cask violently, and set it first on one end, and then upon the other.

855. To Make Barrels Tight. Dissolve in a water-bath 1 pound leather scraps and 1 ounce oxalic acid, in 2 pounds water, and dilute gradually with 3 pounds warm water. Apply this solution to the inside of the barrel, where, by oxidation, it will assume a brown color and become insoluble in alcohol. This coat closes all the pores of the wood, and does not crack or scale off.

Brewing. The art of brewing is simply and easily understood, cleanliness and attention being the principal points to be considered. It consists of five operations, namely: mashing, boiling, cooling, fermenting, and cleaning. The first process is simply to obtain an infusion of the malt. In the second, this infusion of malt is further impregnated with the flavor of the hops in the boiling, which is requisite for the preservation of the beer. In the third, this decoction or infusion is cooled down to the necessary heat for fermentation, which is excited with yeast, and which fills it with carbonic gas, giving to the liquor that pungent taste for which it is esteemed. After this it is fined, or cleansed, to render it fit for drinking.

857. Brewing Utensils. These utensils in a small way (say for a hogshead, or 54 gallons of beer), will consist of a copper capable of containing about 70 gallons; and if the brick edge at the top is made sloping, and covered with lead, it will prevent any waste of the wort in the boiling. A mash tub, with a false bottom about 3 inches above the other bottom, bored full of small holes, to prevent the malt stopping up the hole of the faucet. In many cases, for the sake of economy, an old worn-out birch-broom is cleaned and fastened before the hole of the faucet; and others again have two pieces of wood nailed together, and bored full of holes, which is fitted to the side of the tub, so as to cover the hole of the faucet. Any one of these contrivances is to prevent the malt or grains from flowing out with the wort, which would spoil its transparency. The tub must be sufficiently large to hold 10 or 12 bushels of malt, with plenty of room for mashing or stirring. An underback, to receive the wort from the mash tub. An oar, or rudder, to stir up the malt in the mash tub. Two or three coolers. These should be broad and flat, that the wort may cool quickly; for if the wort is too long cooling, it is likely to become sour in the coolers. These should also be raised a little at one end, that the wort may be run off at the lower end without being disturbed or shaken, and also that the sediment which falls down may not be again mixed with the wort. A fermenting tun. The mash-tub, when emptied of the grains, will also serve for this purpose. Casks, and oak stands for the casks and tubs to be placed on. The whole of these articles should be of a suitable size with the copper, which the cooper will always regulate, or in proportion to the quantity intended to be brewed.

858. Mashing. The purpose of mashing is to convert as much of the flour of the malt as possible into sugar, so that the extract drawn from it may contain the greatest amount of saccharine matter which it is capable of giving. To accomplish this perfectly will depend upon many contingencies—the heat of the water used in mashing, its quality, whether hard or soft, the most perfect mixing of the malt with the water, and the time of their remaining together. High-dried malt does not produce so much saccharine matter as pale malt. On the proper temperature of the liquor used will depend the goodness, flavor, and clearness of the extract drawn. When too high, or near the boiling point, the flour of the malt will be set, forming a kind of paste or starch, and the extract obtained will be little better than water. The surface of the grains after the mashing process is concluded will be covered with specks of white meal. The same appearance also shows itself when unmalted corn has been mixed with the malt. If the temperature be too low, the wort will be poor and devoid of strength, because the heat of the water is not sufficient to convert the flour of the malt into sugar, or to extract the saccharine matter from it. For pale malt the heat of the water must be higher than for brown, and so much the lower in proportion as the malt is browner. Thus, for the pale malt, the heat of the water for the first mash should be 178° Fahr.; for the second, 182°. Pale and amber mixed, or pale malt approaching to amber, 172° for the first mash; second, 178°. All amber, the first 170°; second, 176°. For very brown, or brown malt, such as is used for porter, 154° for the first; second, 164°. When hard water is used, the heat in each case should be about 2° less. An equal portion of pale, amber, and brown, or half pale and half brown—first heat, 160°; second, 166°. The time for the standing of the mash is from an hour and a half to two hours. In the summer months the mash should not stand so long by a quarter of an hour as it does in the winter. Heat the water in the copper to the required degree by Fahrenheit's thermometer. In taking the heat in the copper, if it is too hot, add cold liquor to bring it to the desired degree; but be careful to stir the hot and cold well together and mix it intimately, because the cold water, being heavier than the hot, sinks to the bottom. The heat of the water being now reduced to the proper degree in the tun, the malt must be stirred in gradually. It is best for one person to throw it in whilst another mixes it well and thoroughly by means of the oar, so that there may be no lumps or clots of malt left in it. The remainder of the water should be added by degrees, as the mash becomes too stiff to stir, until the whole is used. Reserve about $\frac{1}{2}$ bushel of the malt to throw over the top when the mashing is finished. Cover the top of the tun with malt-sacks or cloths, to keep in the heat, and let it stand the required time. Turn the tap partially, to allow the wort to run out slowly, and draw off some in a pail or bucket. As the first running will not be clear, it must be put gently back into the tun; and if the second running is not sufficiently clear, turn the tap again, and let it remain a few minutes before drawing it off; then turn the tap partially as before, and draw it off into the underback, which must be placed underneath to receive it. As the wort runs out more slowly, the tap must be turned more fully, until the whole is nearly run out, and the bed of the grains looks dry; then turn the tap, to prevent any more running off. While the mash is standing, the copper should be again filled with water, and heated to the required degree for the second mash; this should be ready by the time the first wort is drawn off; then, with a bowl or ladle, pour over the top of the grains, as gently as possible, about half as much water as for the first; cover the mash-tun, let it remain about ten minutes or a quarter of an hour, and draw it off as before, pouring back the first running until it is fine. The wort from the first mashing is always the best and richest in saccharine or sweet matter. The proportion of wort to be obtained from each bushel of malt depends entirely on the proposed strength of the liquor required. To ale or beer of a superior kind the produce only of the first mashing should be used. For ordinary or usual drinking ale, take the produce of the first and second mashings, mix them well, and ascertain the gravity by a *saccharometer*. This is an instrument used by brewers for ascertaining the strength of wort; it is similar in principle to the hydrometer, but its scale denotes the pounds per barrel in excess of the weight of a barrel of water. The barrel or 36 gallons of water weighs 360 pounds; and, in examining a quantity of wort, if the saccharometer marks 60, it means that a barrel (36 gallons) of the wort would weigh 60 pounds more than a barrel of water, or 420 pounds. It is a sort of specific gravity, in which 360 is the unit instead of 1000; from which it can be seen that a saccharometer gravity of 420, as compared with 360, would be the same as $1166\frac{2}{3}$ true specific gravity as compared with 1000. Some brewers express the strength of their wort by the whole weight of a barrel, others use only the excess of weight; thus, in the example above, some would call it wort of 420 pounds, others would say 60 pounds; either way is plain; the figures showing which plan is adopted. The usual limit for ale or beer is from 50 to 60 pounds, and for a very strong ale from 90 to 120 pounds per barrel. That made at the first gravity will be a brisk, lively and sparkling drink; but the last will be more heavy and glutinous, and can only be imperfectly fermented.

859. Boiling. As soon as the water is taken from the copper for the table-beer, damp the fire with ashes or cinders, and put in the wort. For every bushel of malt used, allow 1 pound hops, previously soaked in water taken from the first mash at 160° of heat; add half of them at first, and the other half after the wort has boiled half an hour. 2 pounds of hops by this method are considered to be equal to 3 pounds used in the ordinary way. The water in which they are steeped is strained off and put into the tun instead of the copper, which preserves the flavor of the hops. Let the wort boil as briskly as possible, for the quicker it is boiled the sooner it will break. Try it occasionally in a glass, and see if it has separated into large flakes; if it has not, boil it a little longer; when nearly ready, it will appear to be broken into fine particles. The extremes of under and over-boiling must be avoided, for when over-boiled it is with difficulty fined again in the casks.

860. **Cooling.** When the wort is ready, damp the fire, and draw it off into the coolers, keeping the hops well stirred to prevent their being burnt to the bottom; strain it through a hair-sieve to take off the hops. The coolers should be as shallow as possible, that the wort may not be too long in cooling, or it may chance to get sour, and should be of the same depth in each, that it may cool equally. When the first wort is drawn off, return the hops again into the boiler, with the wort for the table-beer, and let it boil quickly for one hour and a half; and if 1 pound coarse sugar or molasses, and 1 ounce salt, be added to every 10 gallons wort in the boiling, it will be much improved. When the wort has been cooled down to 75 or 80 degrees of heat by the thermometer (this will depend on the state of the atmosphere, for when the weather is warm it should be cooler), draw it off into the fermenting tun, without disturbing the sediment at the bottom, which gives the ale or beer a disagreeable taste. This is always observed by the Scotch brewers, but others consider that it feeds the beer, which it certainly does, and always use it; for whether it is the oleaginous quality of the hops, or the gluten extracted from the malt, which is precipitated by the boiling, it cannot be of any injury to the wort. If it is the first, it is of essential service to give the full flavor of the hops. In each case it will be thrown off in the working.

861. **Fermentation.** 3 pints good white fresh yeast will be about the quantity required to work a hogshead of beer; but in larger brewings this will depend on the quantity there is in a body, the gravity, and heat of the atmosphere—thus, the lower the gravity, the greater the bulk, and the warmer the weather, the less yeast must be used in proportion to work it, and *vice versa*. 3 pints being sufficient for a hogshead, a gallon will work 4 or 5 hogsheads in a body of the same gravity. First mix the yeast with a gallon or two of the wort, and a handful or two of bean or wheat flour in the fermenting tun; when the fermentation is brisk, pour over another portion, and as soon as the wort is at the proper degree of temperature run it into the tun, reserving out some of the ferment, to feed the beer as occasion may require. When it becomes languid, or if there is sufficient yeast in, it may be left out altogether. The fermentation should be gradual at first; for if it goes on too quickly the beer is likely to become foxed, that is, to have a rank and disagreeable taste. The next morning the beer should have a thin white creamy head; then, with a bowl or ladle, well rouse and mix it together. If, however, the fermentation has not been favorable, add some of the ferment; and if rather cold, wrap some sacks or old carpet round the tun, and place some more sacks over the top; also keep the door and windows closed. Or take a clean cask (the size according to the quantity of the gyle, or brewing), and fill it full of boiling liquor; bung it close, and put in the tun. In the evening rouse the head well in again; the next morning the beer should have what is termed a cauliflower-head; remove with the skimmer any patches of dark-brown yeast, and mix it well up together again. After the yeast has risen to the top, it will form a thick yeasty appearance, which should be skimmed off as soon as it is inclined to fall. A portion should then be taken out, tried with the saccharometer, and noted. If not sufficiently fermented, it should be tried every two hours until it is so, and the head may be skimmed off at the same time. When sufficiently reduced, cleanse it into the casks.

862. **Cleansing.** In cleansing ale or beer, the yeast should be skimmed from the top, and the liquor drawn off gently, so as not to disturb the bottoms. The casks should be plugged a little on one side, that the yeast may work and discharge itself at the bung-hole. A tub or pan must be placed underneath to receive the yeast as it works over. The greatest attention should be paid to the filling up of the casks with the wort that is left, which should be done every half hour at first, and as the working becomes more slow, every 3 or 4 hours, that the yeast may continue to discharge itself, otherwise it will fall to the bottom, and render the beer harsh and unpleasant, and liable to be excited on every change of the weather; but by attending to these precautions, this will be avoided, and the working of the beer will be sooner over. When the yeast has ceased to discharge itself, plug the casks upright, mix a pound of the best hops with some old ale or beer, and scald them in it over the fire. If the ale or beer is required to be drunk soon, this mixture should be added warm, otherwise add it when cold. Mix it well into the cask by means of a long stick, and bung the cask close; make a spile-hole near the bung, and put in a spile rather loosely at first, and after two or three days knock it in firmly.

863. **Important Hints on Brewing.** Small beer will require rather more yeast to work it than strong beer or ale. A portion of the wort at the temperature of 85 degrees should be mixed at first with the yeast. When the fermentation has commenced, the rest of the wort may be run into the tun at the heat of 75 degrees. It will not work so long nor so strongly as ale, and may be casked the next day. Attend to the filling of the cask as directed for ale. In about two days the fermentation will have subsided, and the cask should then be bunged close. The fermentation will always show whether the degrees of heat have been well taken, and the extract well made. If too high, the air-bladders on the head will be about as large as a dollar piece. If too low, there will be few or no bladders, or very small ones; but when well taken they will be in size about that of a 2 cent piece. The proportions of hops used for beer should be in accordance with the time it is to be kept. If for immediate use, 3 pounds will be sufficient for a coomb of malt (4 bushels). From 1 to 2 years, 4 pounds; old beer, 5 or 6 pounds. The same if the wort is very rich; or in proportion to its gravity use more hops, because beer or ale made from rich wort is always intended for long keeping. In general, 4 or 5 pounds of hops per coomb (4 bushels) is used for ales; but for porter, 5 or 6 pounds, and for bitter ale, about 8 or 10 pounds; but in all cases care should be taken that the hops are of the best quality. The private brewer will find about ¼ pound of raspings of quassia equivalent to 6 pounds of hops for preserving ale and imparting a pleasant bitter. Beer brewed for immediate use may be made from all pale malt, as it is more readily fermented than that from the browner sorts. It will not keep so well, and may be brewed almost in the hottest weather, as it need not be cooled below 70 or 75 degrees. A mixture of pale and amber malt should always be used for keeping beer, and the wort cooled down to 60 or 70 degrees before it is put into a state of fermentation; hence, from Autumn to Spring, or the months of October to March, have ever been deemed the most favorable months for brewing the best malt liquor, the former being considered the most fitted, as the beer has so many cold months immediately succeeding, for it to ripen and grow fine in; besides, it does not want such watching and tending as the March beer does, in putting in and taking out the spile or peg on every change of the weather. The proportion of wort to be obtained from every bushel of malt will depend entirely on the proposed strength of the liquor required. For ale or beer of a superior kind, the produce of the first mashing only should be used; but if the ordinary or usual driking ale is wanted, take the produce of the first and second mashings, and use the third for table beer.

864. **Flavoring Beer.** There are several simple and innoxious articles which can be used for this purpose by the private brewer—namely, Spanish liquorice, liquorice root, cardamom and caraway seeds, and dried orange peel powdered; these are very excellent when used judiciously. Honey is also an excellent assistant to beer and ale; about 2 pounds to a quarter (8 bushels) of malt being put into the copper just before the wort is turned out, or long enough to melt and incorporate with the mass. The same plan should be adopted with everything used for this purpose—that is, throwing it in when the wort is at the full boiling point, for then it will not fall to the bottom without mixing. When, however, Spanish liquorice is used, it will be necessary to tie it in a net bag and suspend it. Salt and ground ginger, or salt and any other spice, are excellent for cleansing beer.

865. **Porter Brewing for Families.** To make this beverage, three sorts of malt are required, namely: pale, brown, and blown malt. The peculiar flavor of this liquor is given by the brown and blown malt, and no other material or ingredient whatever is required different from other sorts of beer. The mixture of malt may be composed of half pale or amber, and half brown malt; or, take for a hogshead, 4 bushels of pale or amber malt, 2 of brown, and 14 pounds of patent blown malt, and 6 pounds of the best brown hops. These proportions will make excellent porter, but the following may be used for a second-rate quality:—2½ bushels of amber, 1½ bushels of brown malt, and 4 pounds of hops, with sufficient burnt sugar (*see No.* 694) to give the desired color; or it may be brewed with all amber malt, using blown malt, or sugar coloring, instead of the brown malt. The water for mashing must be lower than for beer or ale, and be reduced to 164 or 166 degrees for the first mash, according to the instructions already laid down. All the processes are conducted the same as for beer or ale, with this exception, that blown malt is boiled with the wort in a copper, and the second malt, if boiled separate, should be boiled violently for 2 or 3 hours; and as there is generally but one quality of porter, the two kinds of wort are run together into the tun. 28 gallons of cold water may be run into the tun for table porter, which should be managed as table beer. If the color is not sufficiently high it may be heightened by using a pound of Spanish liquorice with the wort in the boiler, or by the addition of burnt sugar (*Caramel, see No.* 694.)

866. **Hints on Fermentation.** The fermentation of beer or ale is a very important part of the process of brewing. The quantity of extract obtained from the malt depends greatly upon the heat of the water used for mashing, and on the mashing process being properly conducted; but whether that extract be rich or poor, the flavor of the beer or ale, and its ultimate success in the cellar, depends upon the wort being properly and sufficiently fermented in the tun and casks. Fermentation increases the heat and decreases the gravity of the wort, altering altogether its original character by a decom-

position of its parts, or a conversion of its saccharine principle into alcohol, which gives to it that vinous pungency for which it is esteemed. If the fermentation is not carried far enough, the abundant sweet principle of the wort will not be sufficiently changed to give it the necessary vinous taste, and it will be sickly and cloying, deficient of strength, and liable to become ropy. When the fermentation is carried too far in the tun, the vinous flavor is partly lost; and if still lower, the yeast becomes, as it were, fixed in it, from the ale or beer having lost its natural energy to throw it off, and it will have a flat, stale, and disagreeable taste. Fretting (*see No.* 757) then ensues in the cask, and from being deficient of body it soon becomes sour, unless speedily drunk. All beer for keeping should be fermented in the tun to about one-fourth its original gravity, in a temperature of the gyle not exceeding 70 degrees. Lighter beer about one-third; but in no case should it be allowed to reach so far as one-half. In winter, the fermentation of weak beer must not be carried quite so far as in the summer, as more unfermented matter must be left to nourish it in the cask during the cold weather, which will counteract its ripening. Some allowance should also be made for the time the ale or beer is intended to be kept. Strong wort will bear a greater proportionate fermentation than weak wort, and consequently be stronger and more sparkling. Beer of this kind, intended to be kept, should be fermented so low as to ensure transparency and softness, with a proper degree of strength, for it will have time to bring itself round. Still, care must be taken to leave a sufficient quantity of unfermented matter for the supply of the gradual decomposition, the quantity left being proportionate to the time the beer is intended to be kept. Wort of 50 or 60 degrees gravity (*see No.* 858) will keep well for 2 or 3 years, if reduced to two-fifths, or at least one-fourth. Ale is not fermented so much as beer, therefore a considerable portion of the saccharine matter still remains in the liquid, apparently unaltered. In conducting this process, both the thermometer and saccharometer must be the guide;—the last is indispensable. The results given by these should be carefully noted in a book kept for the purpose, with the heat of the atmosphere at the time the observations are made, which will serve as a guide for any future brewing. As soon as the head forms a brown, thick, yeasty appearance, and is inclined to fall, it must be immediately skimmed off. Particular attention must be paid to this point. It is at all times better to skim it before it begins to drop, than allow it to pass again through the beer, which will give it a rank, disagreeable taste, termed "yeast bitten;" neither will it fine well in the cask. After the head is skimmed off, a portion should then be taken out, tried by the saccharometer, and noted; and if it is not sufficiently fermented it should be roused well up, and skimmed every two hours until the required gravity is nearly attained, when it should be watched with the greatest attention, and cleansed with a little salt and bean-flour, and any other flavoring ingredient may then be added, such as ground ginger, cardamom, caraway seeds, &c., and well mixed with it immediately it is reduced to the desired point.

867. The Acetous Fermentation may arise from premature fermentation, through the mashing heat being taken too low, when it may commence in the tun, underback, or coolers. If in the mash tun, the wort will ferment very rapidly, and produce a large quantity of yeast; but of course the liquor will be soured, therefore less yeast will be required to ferment it. When the first mash is affected, all the subsequent ones will share the same fate, and no extra quantity of hops or boiling that may be given to it will restore it to a sound condition. It may also arise from the mashing heat being taken too high. When this is the case, the fermentation is languid, the yeast head is very low, and appears brown or fiery, accompanied with a hissing noise, and occasionally it will appear as if boiling. A larger quantity of yeast than usual is necessary to be added to wort of this description, to force the fermentation, and to discharge the yeast freely, in order that as little as possible may remain in the liquor, which would otherwise fret and become sour. The acetous fermentation may also arise from premature fermentation, either in the underback or coolers; hence, fretting ensues, and the liquor continually generates acidity.

868. To Correct Acidity in Beer. Acidity in beer may be neutralized by chalk, lime, alkalies, &c.; but it cannot be totally destroyed without spoiling the liquor.

869. Bittern. This is an adulterating mixture employed by brewers to impart a false bitter and strength to their liquors. Boil 4 parts Spanish liquorice in sufficient water until dissolved, and evaporate to the consistence of cream. Then add to it 1 part extract of quassia, 1 part powdered sulphate of iron, 2 parts extract of cocculus indicus, and 8 parts molasses.

870. Bitter Balls. These are used as a fraudulent substitute for hops in making beer, and are different in composition, to suit different kinds of malt liquor.

For ale: 2 pounds powdered gentian, and 1 pound extract of gentian, mixed with sufficient molasses to make a paste. Divide into ½ pound rolls.

For pale ale: 1 pound crude picric acid, 3½ pounds ground chamomiles, and ½ pound grains of Paradise, mixed with syrup.

For porter or stout: either of the above, with the addition of 1½ pounds Spanish liquorice softened with a little boiling water.

871. Fining for Ale or Beer. It frequently happens that malt liquor, especially porter, with all the care bestowed upon it in brewing, will not turn out sufficiently fine to meet the taste and eye of the consumer, in which case it is usually subjected to the operation of clarifying. For this purpose 1 ounce isinglass is put into 1 quart weak vinegar, or still better, hard beer, and when dissolved, a sufficient quantity of good beer may be added to make it measure 1 gallon. This mixture is called finings, 1 to 2 pints of which is the proper quantity for a barrel. The method of using it, is to put the finings into a bucket, and to gradually add some of the beer, until the bucket is three parts full, during which time it is violently agitated with a whisk, and this is continued until a good frothy head is raised upon it, when it is thrown into the barrel of beer, and the whole well stirred up, by means of a large stick shoved in at the bung-hole. In a few days the beer will usually become fine.

872. To Ascertain Whether Malt Liquor may be Clarified by Fining. In some bad sorts of beer, isinglass will have no effect. This may be ascertained beforehand, by trying some in a long glass tube, or vial, with a little of the finings. These should be well shaken together, and then set aside for a short time, when it will be found that the finings will rise to the top, leaving the central portion of the beer clear, if it be in a proper condition for clarifying; but if, on the contrary, they sink to the bottom, and the liquor still keeps foul, no quantity of finings, however great, will ever clarify it.

873. To Clarify Obstinate Ale. This latter defect may be remedied by proceeding to fine it after the manner above described, and then adding, after the finings have been well rummaged up, either 1 spoonful oil of vitriol or gum catechu, dissolved in ½ pint warm water, again stirring well for a quarter of an hour. Or 1 or 2 ounces tincture of catechu may be used instead, mixed with a little water. Either of these additions acts chemically on the finings, in the same way as good beer does, precipitating them along with the foulness, and thus brightening the liquor. The addition of a handful of hops, previously boiled for 5 minutes in a little of the beer, and then added to the barrel, and the whole allowed to stand for a few days, before proceeding to clarify it, will generally have the same effect.

874. To Ripen Beer. The addition of a small lump of white sugar to each bottle of ale or beer, and a tea-spoonful of moist sugar to each bottle of porter at the time of corking, will render it fit for drinking in a few days in ordinary weather. A raisin or lump of sugar candy is often added to each bottle with a like intention. The Parisians bottle their beer one day, and sell it the next. For this purpose, in addition to the sugar as above, they add 2 or 3 drops of yeast. Such bottled liquor must, however, be drunk within a week, or else stored in a very cold place, as it will otherwise burst the bottles, or blow out the corks.

875. To Give Beer the Appearance of Age. The addition of a very little diluted sulphuric acid to new beer will give it the appearance of being 1 or 2 years old. Copperas, alum, sliced lemons, oranges, and cucumbers, are also frequently employed by brewers for the same purpose.

876. Beer Heading. Alum and green copperas equal parts, both in fine powder; mix. Or, alum, copperas, and common salt, of each equal parts; mix. Used by brewers to make their beer keep its head.

877. To Remedy Mustiness in Beer. To each hogshead add 1 pound new hops boiled in a gallon of the liquor, along with 7 pounds newly-burnt charcoal coarsely bruised, and a 4 pound loaf of bread cut into slices and toasted rather black; rouse well every day for one week, then stir in moist sugar 3 or 4 pounds, and bung down for 2 weeks.

878. To Remedy Flatness in Beer. Stir a few pounds of moist sugar into each hogshead; fermentation will ensue in a few days, and the liquor become brisk. On the small scale, the addition of a few grains carbonate of soda or prepared chalk to each glass will make the liquor brisk and carry a head; but it must be drunk within a few minutes, else it becomes again flat. This is an excellent method when home-brewed beer becomes sour and vapid.

879. To Recover Frosted Beer. Frosted beer is best recovered by the addition of a few hops boiled in a little sweet wort; or by adding a little moist sugar or molasses to induce a fresh fermentation.

880. Foxing or Bucking Beer. Add some fresh hops, along with some bruised mustard seed, to the beer. Some persons add a little made mustard, or solution of alum or catechu, or a little diluted sulphuric acid, and stir it well; and in a week or 10 days afterwards, further add some bean-flour, molasses, or moist sugar.

881. To Remedy Ropiness in Beer. Add a little infusion of catechu and some fresh hops to the beer, and in a fortnight stir well, and the next day fine it down.

882. German Beer Bouquet. According to Dr. Boettger, this liquor consists of a solution of the essential oil of lemons in light petroleum oil, and a coarse fusel oil, containing spirit colored by turmeric.

883. Spring Beer. Boil down 3 small bunches each of sweet fern, sarsaparilla, wintergreen, sassafras, prince pine, spice wood, in 8 gallons water to 6 gallons of decoction or extract; strain; 4 gallons of water boiled down to 3 gallons of decoction, with ½ pound hops; strain; mix the two extracts or decoctions together; dissolve in them 1 gallon of molasses, and, when cooled to 80° heat, 1½ pound of roasted bread soaked in fresh brewers' yeast; fill up a 10-gallon keg; when fermentation is over mix with it the white of 1 egg beaten to froth; bung it, and bottle when clear.

884. Spruce Beer. Boil 9½ gallons of water; let it cool down to 80° Fahr., and then dissolve 9 pounds of sugar in it, having previously mixed with it 1 ounce of essence of spruce; then add 1 pint of good brewers' yeast, and pour it in a 10-gallon keg until fermentation is over; then add a handful of brick powder and the white of 2 eggs beaten to a froth; mix with the beer, and let it stand till clear, then bottle.

885. To Make White Spruce Beer. Dissolve 10 pounds loaf sugar in 10 gallons boiling water, add 4 ounces essence of spruce; when nearly cold add ½ pint yeast. Keep in a warm place. Next day strain through flannel, put into bottles and wire the corks.

886. To Make Wood's Spruce Beer. Boil ½ pint essence of spruce, 5 ounces each of bruised pimento and ginger, and 5 or 6 ounces hops in 3 gallons water for 10 minutes. Then add 3 quarts molasses and 11 gallons warm water. When lukewarm add 1 pint yeast; ferment for 24 hours and bottle, as in last receipt. This will also make a white beer by substituting an equivalent of loaf sugar instead of the molasses.

887. To Make Spruce Beer. Take 2 ounces each hops and chips of sassafras root, 10 gallons water; boil twenty minutes, strain, and turn on, while hot, 1 gallon good molasses, and add 2 table-spoonfuls each essence of ginger and essence of spruce; 1 table-spoonful pounded allspice. Put into a cask, and when cold enough add 1 quart yeast; let it stand 24 hours; draw it off or bottle it.

888. Essence of Spruce. Take of the young branches of black spruce (abies nigra), make a decoction with water (*see No.* 34) and evaporate to the consistence of molasses. This is used for fabricating spruce beer—a right pleasant drink when it is fresh.

889. Root Beer. Take sarsaparilla (American), 2 pounds; spice wood, ½ pound; guaiacum chips, 1 pound; birch bark, ½ pound; ginger, ½ ounce; sassafras, 4 ounces; prickly-ash bark, ½ ounce; hops, 1 ounce. Boil for 12 hours over a moderate fire, with sufficient water, so that the remainder shall measure 5 gallons, to which add tincture of ginger, 8 ounces; oil of wintergreen, 1 ounce; alcohol, 1 quart. This prevents fermentation. To make root beer, take of this decoction 1 quart; molasses, 8 ounces; water, 2½ gallons; yeast, 4 ounces. This will soon ferment and produce a good drinkable beverage. The root beer should be mixed, in warm weather, the evening before it is used, and can be kept for use either bottled or drawn by a common beer-pump. Most people prefer a small addition of wild cherry bitters or hot drops to the above beer. (*See Nos.* 821 *and* 891.)

890. Puffer's Root Beer. Prince's pine, 2 ounces; wild cherry, 2 ounces; hemlock bark, 2 ounces; wintergreen, 4 ounces; sassafras bark, 4 ounces; birch bark, 4 ounces; spice bark, 4 ounces; Jamaica ginger, 2 ounces; white mustard seed, 1 ounce. Put in a percolator and cover with boiling water; let it stand till cold, then strain; add to it enough boiling water to make 4 gallons. Take 1 gallon of this, add 1 gallon of molasses, or the same amount of syrup; to this add 8 gallons of water and about 1 pint of yeast. 1 pint of alcohol added will much improve its flavor, and it will keep longer.

891. Hot Drops. Take of tincture of myrrh, 1 ounce; tincture of capsicum, 2 ounces.

892. To Make Ottawa Root Beer. Take 1 ounce each sassafras, allspice, yellow dock, and wintergreen; ½ ounce each wild cherry bark and coriander; ¼ ounce hops and 3 quarts molasses. Pour boiling water on them; macerate for 24 hours; then filter and add ½ pint yeast. Add about 6 gallons water, or to taste. In 24 hours it is ready for use.

893. To Make Superior Ginger Beer. Take 10 pounds of sugar, 9 ounces lemon juice, ½ pound honey, 11 ounces bruised ginger root, 9 gallons water, 3 pints yeast. Boil the ginger half an hour in 1 gallon water; then add the rest of the water and the other ingredients, and strain it when cold. Add the white of an egg beaten, and ½ an ounce essence of lemon. Let it stand 4 days, then bottle, and it will keep many months.

894. To Make Ginger Beer. Put into 1 gallon boiling water, 1 pound lump sugar, 1 ounce best unbleached Jamaica ginger well bruised, ¾ ounce cream of tartar and 2 lemons sliced; stir the ingredients frequently in a covered vessel until lukewarm; then add 1½ or 2 ounces yeast, and keep it in a moderately warm place so as to excite a brisk fermentation; the next day rack and strain through flannel; let it work for a day or two, then strain it again and bottle, wiring down the corks.

895. Ginger Beer Without Yeast. Boil 1½ pounds bruised ginger in 3 gallons water half an hour; then add 20 pounds white sugar, 1 pint lemon or lime juice, 1 pound honey, and 17 gallons water; strain through a cloth. When cold add the white of 1 egg, and ¼ fluid ounce essence of lemon; after standing 3 or 4 days, bottle.

896. To Make Ginger Pop. Take 5½ gallons water, ¾ pound ginger root bruised, ½ ounce tartaric acid, 2½ pounds white sugar, whites of 3 eggs well beaten, 1 small tea-spoonful lemon oil, 1 gill yeast; boil the root for 30 minutes in 1 gallon of the water, strain off, and put the oil in while hot; mix. Make over night; in the morning skim and bottle, keeping out sediments.

897. To Make Ginger Pop. Take 2 ounces best white Jamaica ginger root, bruised; water, 6 quarts; boil 20 minutes, strain, and add 1 ounce cream tartar, 1 pound white sugar; put on the fire and stir until all the sugar is dissolved, and put in an earthen jar; now put in ½ ounce tartaric acid, and the rind of 1 lemon; let it stand until 70° Fahr., or until you can bear your hand in it with comfort; then add 2 table-spoonfuls of yeast, stir well, bottle for use and tie the corks. Make a few days before it is wanted for use.

898. Wahoo Beer. Boil for 6 hours in 4 gallons water, 1 ounce each sarsaparilla, Solomon's seal, nettle root, and sassafras; 2 ounces each burdock root, comfrey root, and Prince's pine; 2 ounces sweet fern, ½ ounce wintergreen, and 4 raw potatoes cut up fine. Strain, and add 1 quart molasses for each 3 gallons of the strained liquor, and a browned loaf of bread. When cool, put in 1 pint of good yeast, and let it ferment for 24 hours. It will then be ready to be put in bottles or a keg.

899. Lemon Beer. Put into a keg 1 gallon water, 1 sliced lemon, 1 table-spoonful ginger, 1 pint good syrup, and ½ pint yeast. In 24 hours it will be ready for use. If bottled the corks must be tied down.

900. Imperial Pop. Cream of tartar, 3 ounces; ginger, 1 ounce; white sugar, 24 ounces; lemon juice, 1 ounce; boiling water, 1½ gallons; when cool, strain, and ferment with 1 ounce of yeast, and bottle.

901. Girambing, or Limoniated Ginger Beer. Boil 4½ ounces of ginger with 11 quarts water; beat up 4 eggs to a froth, and add them with 9 pounds sugar to the preceding. Take 9 lemons, peel them carefully, and add the rind and juice to the foregoing. Put the whole into a barrel, add 3 spoonfuls of yeast, bung down the barrel, and in about 12 days bottle it off. In 15 days it will be fit for drinking, but it improves by keeping.

902. Ginger Beer Powders. Fine powder of Jamaica ginger, 4 or 5 drachms; bicarbonate of soda, 3½ ounces; refined sugar in powder, 14 ounces; essence of lemon, 30 drops; mix, and divide into 5 dozen powders. (Or 4 to 5 grains of ginger, 26 of bicarbonate of soda, 112 of sugar, and ½ drop of essence of lemon, in each powder.) In the other powder put 32 grains of tartaric acid; or 35 grains if a more decidedly acidulated beverage is required. Or from 30 to 33 grains of citric acid.

903. Spruce Beer Powders. In each blue paper put 5 scruples of powdered sugar, 28 grains of bicarbonate of soda, and 10 grains essence of spruce. In each white paper 30 grains of tartaric acid.

904. Sherbet. Take 8 ounces carbonate of soda, 6 ounces tartaric acid, 2 pounds loaf sugar (finely powdered), 3 drachms essence of lemon. Let the powders be very dry. Mix them intimately, and keep them for use in a wide-mouthed bottle, closely corked. Put 2 good-sized tea spoonfuls into a tumbler; pour in ½ pint of cold water, stir briskly, and drink off.

905. Raspberry Shrub. 1 quart vinegar, 3 quarts ripe raspberries. After standing a day, strain it, adding to each pint a pound of sugar, and skim it clear, while boiling about half an hour. Put a wine-glass of brandy to each pint of the shrub, when cool. Two spoonfuls of this, mixed with a tumbler of water, is an excellent drink in warm weather and in fevers.

906. Aerated or Effervescing Lemonade. This may be made by putting into each bottle (soda water bottle) 1 ounce or 1½ ounces syrup of lemons, and filling it up with simple aerated water from the machine. (The syrup is made by dissolving 30 ounces lump sugar in 16 ounces of fresh lemon juice, by a gentle heat. It may be aromatized by adding 30 or 40 drops of essence of lemon to the sugar; or by rubbing part of the sugar on the peel of 2 lemons; or by adding to the syrup an ounce of a strong tincture of fresh lemon peel, or of the distilled spirit of the same.)

907. Effervescing Lemonade, without a Machine. Put into each bottle 2 drachms of sugar, 2 drops of essence of lemon, ½ drachm bicarbonate of potash, and water to fill the bottle; then drop in 35 or 40 grains of citric or tartaric acid in crystals, and cork immediately, placing the bottles in a cool place, or preferably, in iced water.

908. Plain Lemonade in Powder. (For ten gallons.) ½ pound tartaric acid in powder, 16 pounds sugar in powder, 1½ drachms oil of lemons. Rub and mix well. 1 ounce of this powder makes ½ pint of lemonade.

909. To Make Superior Lemonade. Take the rind of 2 lemons, juice of 3 large lemons, ½ pound loaf sugar, 1 quart boiling water. Rub some of the sugar, in lumps, on two of the lemons until they have imbibed all the oil from them, and put it with the remainder of the sugar into a jug; add the lemon juice (but no pips), and pour over the whole a quart boiling water. When the sugar is dissolved, strain the lemonade through a piece of muslin, and, when cool, it will be ready for use. The lemonade will be much improved by having the white of an egg beaten up with it.

910. To Make Orangeade. Take of dilute sulphuric acid, concentrated infusion of orange peel, each 12 drachms; syrup of orange peel, 5 fluid ounces. This quantity is added to 2 imperial gallons of water. A large wine-glassful is taken for a draught, mixed with more or less water, according to taste. This refreshing drink not only assuages the thirst, but has, moreover, strong antiseptic and anti-diarrhœa properties.

911. Imitation Lemon Juice. This is an excellent substitute for lemon juice, and keeps well in a cool place. Dissolve 1¼ ounces citric acid, 45 grains carbonate of potassa, and 2¼ ounces white sugar in 1 pint cold water; add the yellow peel of a lemon, and, in 24 hours, strain through muslin or a hair sieve. Instead of the lemon peel, 15 or 16 drops of oil of lemon may be used to flavor.

912. Imitation Lemon Juice. Citric or tartaric acid, 2¼ ounces; gum, ¼ ounce; pieces of fresh lemon peel, ½ ounce; loaf sugar, 2 ounces; boiling water, 1 quart; macerate with occasional agitation till cold, and strain. Excellent.

913. Imitation Orange Juice. Dissolve 1 ounce citric acid and 1 drachm carbonate of potassa in 1 quart water, and digest in the solution the peel of half an orange until sufficiently flavored; then sweeten with honey or white sugar. Instead of the orange peel, 5 or 6 drops of oil of orange peel, with ½ fluid ounce tincture of orange peel, may be used.

914. To Keep Lemon Juice. Buy lemons when cheap and keep them in a cool place two or three days; roll them to make them squeeze easily. Squeeze the juice in a bowl, and strain it through muslin which will not permit a particle of the pulp to pass through. Have ready ½ and ¼ ounce phials, perfectly dry. Fill them with the juice so near the top as only to admit ½ tea-spoonful of sweet oil in each, or a little more if for larger bottles. Cork them tight, and put them in a cool dark place. When you want the juice, open such a sized bottle as you will use in a few days. Wind some clean cotton on a skewer, and dip it in, to absorb all the oil. When the oil is removed the juice will be as fine as when first bottled.

915. Portable Lemonade. Take 1 pound finely-powdered loaf sugar, 1 ounce tartaric or citric acid, and 20 drops essence of lemon. Mix, and keep very dry. 2 or 3 tea-spoonfuls of this stirred briskly in a tumbler of water will make a very pleasant glass of lemonade. If effervescent lemonade be desired, 1 ounce carbonate of soda must be added to the above.

916. Lemonade Powders. Pound and mix together ½ pound loaf sugar, 1 ounce carbonate of soda, and 3 drops oil of lemon. Divide the mixture into 16 portions, wrapped in white paper. Then take 1 ounce of tartaric acid, and divide into 16 portions, wrapping them in blue paper. Dissolve one of each kind in half a tumbler of water, mix the two solutions together, and drink while effervescing.

917. Lemon Soda Nectar. Juice of 1 lemon, ½ tumblerful of water, powdered white sugar to taste, ½ small tea-spoonful of carbonate of soda. Strain the juice of the lemon, and add to it the water, with sufficient white sugar to sweeten the whole nicely. When well mixed, put in the soda, stir well, and drink while in an effervescing state.

918. Milk Punch. Take 1 table-spoonful white sugar, 2 table-spoonfuls water, 1 wine-glass cognac brandy, ½ wine-glass Santa Cruz rum, ½ tumblerful shaved ice. Fill with milk, shake the ingredients well together, and grate a little nutmeg on top.

919. Brandy Punch. Take 1 table-spoonful raspberry syrup, 2 table-spoonfuls white sugar, 1 wine-glass water, 1½ wine-glass brandy, ½ small sized lemon, 2 slices of orange, 1 piece of pineapple. Fill the tumbler with shaved ice, shake well, and dress the top with berries in season; sip through a straw.

920. Whiskey Punch. Take 1 wine-glass whiskey (Irish or Scotch), 2 wine-glasses boiling water, sugar to taste. Dissolve the sugar well with 1 wine-glass of the water, then pour in the whiskey, and add the balance of the water, sweeten to taste, and put in a small piece of lemon rind, or a thin slice of lemon.

921. Claret Punch. Take 1½ table-spoonfuls of sugar, 1 slice of lemon, 2 or 3 slices of orange. Fill the tumbler with shaved ice, and then pour in the claret, shake well, and ornament with berries in season. Place a straw in the glass.

922. Sherry Cobbler. Take 2 wine-glasses of sherry, 1 table-spoonful of sugar, 2 or 3 slices of orange. Fill a tumbler with shaved ice, shake well, and ornament with berries in season.

923. Egg Nogg. Take 1 table-spoonful of fine sugar, dissolved with 1 table-spoonful cold water; 1 egg, 1 wine-glass Cognac brandy, ½ wine-glass Santa Cruz rum, ½ tumblerful of milk. Fill the tumbler ½ full with shaved ice, shake the ingredients until they are thoroughly mixed together, and grate a little nutmeg on top.

924. Bottle Cocktail. To make a delicious bottle of brandy cocktail, use the following ingredients: ⅔ brandy, ⅓ water, 1 pony-glass of Bogart's bitters, 1 wine-glass of gum syrup, ½ pony-glass of Curaçoa. Whiskey and gin cocktails, in bottles, may be made by using the above receipt, and substituting those liquors instead of brandy.

925. Brandy Smash. ½ table-spoonful of white sugar, 1 table-spoonful water, 1 wine-glass of brandy. Fill ⅔ full of shaved ice, use two sprigs of mint, the same as in the receipt for mint julep. Lay two small pieces of orange on top, and ornament with berries in season.

926. Santa Cruz Sour. 1 table-spoonful fine sugar, 1 wine-glass Santa Cruz rum, juice of ½ a lemon. Put the ingredients in a small tumbler ⅔ full of shaved ice, stir, and strain into a claret glass, and dress with thin slices of lime or lemon, and fruit in season.

927. Mulled Wine with Eggs. 1 quart of wine, 1 pint of water, 1 table-spoonful of allspice, and nutmeg to taste; boil them together a few minutes; beat up 6 eggs with sugar to your taste; pour the boiling wine on the eggs, stirring it all the time. Be careful not to pour the eggs into the wine, or they will curdle.

928. Regent Punch. 14 each lemons and oranges, the rinds only, 18¾ drachms ground cinnamon, ½ drachm ground cloves, 2 drachms ground vanilla. Cut, macerate for 24 hours with 2 gallons pure Cognac, and 2 gallons pure Jamaica rum. Strain, press, and add 12 pounds of sugar, boiled with 6 gallons water; skim, and add to the syrup 2 ounces green tea; let it cool, and add the juice of 60 lemons and 14 oranges. Filter through Canton flannel.

929. Bottle Wax. Shellac, 2 pounds; resin, 4 pounds; Venice turpentine, 1½ pounds; red lead, 1½ pounds. Fuse the shellac and resin cautiously in a bright copper pan, over a clear charcoal fire. When melted add the turpentine, and lastly, mix in the red lead. Pour into moulds, or form sticks of the desired size on a warm marble plate. The gloss may be produced by polishing the sticks with a rag until they are cold.

930. Corking. Little can be said with regard to the corking of bottles, beyond stating the fact that common, cheap corks, are always dear; the best corks are soft, velvety, and free from large pores; if squeezed they become more elastic and fit more closely. If good corks are used, of sufficiently large size to be extracted without the corkscrew, they may be employed many times in succession, especially if they are soaked in boiling water, which restores them to their original shape, and renews their elasticity. The most common mode of fastening down corks is with the gingerbeer knot, which is thus made. First the loop is formed as in Fig. 1, then that part of the string which passes across the loop is placed on the top of the cork, and the loop itself passed down around the neck of the bottle, and by pulling the ends of the cord is made tight beneath the rim; the ends of the string are finally brought up, and tied either in a double knot or in a bow on the top of the cork. When ginger-beer is made at home it will be found most advantageous to use the best corks, and to tie them down with a bow, when both corks and strings may be made use of repeatedly. For effervescent wines, such as champagne, gooseberry, &c., which require to be kept a longer time, and are more valuable, a securer knot is desirable, which may be made thus: A loop, as in Fig. 2, is first formed, and the lower end is then turned upwards and carried behind the loop as shown in Fig. 3; it is then pulled through the loop as in Fig. 4, and in this state is put over the neck of the bottle; the part *a* being on one side, and the two parts of the loop on the other; on pulling the two ends the whole becomes tight round the neck, and the ends, which should

Fig. 1.

Fig. 2.

Fig. 3.

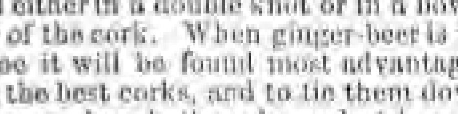


Fig. 4

Fig. 5.

be quite opposite, are to be brought up over the cork, twice twisted, as in Fig. 5, and then tied in a single knot.

931. Distillation of Whiskey and New England Rum. The process of distillation commences with the fermentation of grain or molasses by the presence of yeast, and this is called mashing, or preparing the mash. Strictly speaking, indeed, the spirits are not produced by distillation: that is done by the previous step of fermentation, and distillation merely separates the spirits from the mixture in which they already exist. The object of fermentation is to convert the starchy principle of the grain into sugar, or to saccharify it. After being agitated for 2 or 3 hours, the saccharine infusion, called wort, is drawn off from the grains and cooled. To this wort is now added a certain quantity of yeast or leaven, which induces the vinous fermentation, and resolves the saccharine matter into alcohol and carbonic acid, accompanied by a rise of temperature. The alcoholic mixture which results is called the wash, and is now ready for distillation.

932. How to Prepare Yeast for Rye Whiskey or New England Rum. To prepare yeast for 80 gallons mash, take 2 pounds of wheat meal and dilute it with sufficient warm water to make a thin paste. Then boil 2 ounces of hops in a quart of water, and when cold take out the hops and throw them away. Then dilute 1 quart of malt in a quart of water. Mix, cold, the hop water, paste and malt well together, and add half a pound of leaven. Cover the jar containing the mixture with a piece of cloth, and keep it 3 or 4 hours in some warm place until it rises. The fermentation will be perfect after the whole has arisen and then sunk down. Then add 2 gallons of the mash, stir the whole, mix it with 80 gallons of the mash, and begin the fermentation. This receipt is the very best for rye whiskey.

933. To Prepare Yeast for New England Rum. To 80 gallons mash, add 1 gallon brewers' yeast and ½ pound carbonate of ammonia dissolved in a pint of water. Stir well, and begin the fermentation. Good for New England rum.

934. To Prepare Yeast for Rye Whiskey. To 80 gallons of mash, add 1 gallon yeast, 5 quarts of malt, and 1 pound of molasses. Dilute the malt with 2 quarts of water, and add the molasses. Keep the whole in a warm place until it rises, as described in No. 931. Add the yeast to the mash and stir; afterwards add the molasses and malt and stir again. Then begin the fermentation. Good for rye whiskey.

935. How to Prepare Mash for New England Rum. For a still by steam or fire. To prepare 80 gallons mash, reduce the molasses 18 degrees by the saccharometer, add yeast No. 932, and stir well. Let it ferment at a temperature of 75° Fahrenheit, until the mash is reduced to 0. But as it is very difficult to get such a reduction, the operator may begin to distill when the mash marks 2 or 3 degrees by the saccharometer. Charge three-fourths of the still, and begin distilling.

936. How to Prepare Mash for Rye Whiskey. For a still by steam or fire. To prepare 80 gallons mash, grind the rye into coarse powder, then charge the fermenting tubs in the proportion of 110 pounds of rye to 80 gallons of water, and mix yeast No. 931 or 933. Let it ferment at a temperature of 75° or 80° Fahr., until the fermentation is completed. The fermentation will be perfect after the mash rises and sinks. When this is done, charge three-fourths of the still and begin distilling. In preparing the mash, the operator may use all *rye*, as directed above—this makes the best quality of whiskey—or use three-fifths rye and two-fifths corn, or three-fifths corn and two-fifths rye.

937. Distillation with or without a Heater. Distillers usually employ a heater to hasten the process of distillation. When the heater is employed, the mash passes from the fermenting tubs into the heater. During the time occupied in distilling over the charge of the still, it is necessary to keep a heat of 125 degrees in the heater. The mash passes directly from the heater into the still by means of a pipe or gutter, according to the general arrangement of the apparatus. Distill until the spirit which runs from the worm marks 10 degrees below proof. This first run is called high wine. Then remove the receiver that contains the high wine, and substitute another. Continue to distill until the low wine ceases to blaze when it is thrown in the fire. Whenever this occurs, stop the operation, and keep the low wine for the next distillation. Then clean the still and charge it with fresh mash. When the operator does not employ the heater, the mash passes from the fermenting tubs immediately into the still. No uniform disposition is necessary for the fermenting tubs or heater; all depends upon the general arrangement of the apparatus. The distiller need not be informed that the apparatus must be arranged so as to save labor. If the mash tubs are above the still, connect them by a gutter or pipe; if on a level with the still, employ a hand pump.

938. How to Pack a Rectifying Tub. To rectify from 10 below proof to 20 above proof. **30 bushels of maple charcoal are required for a tub seven feet high and four feet in diameter; a tub of this size will give a clear bed of 14 inches. At two inches from the bottom of the tub place a false bottom perforated with ¼-inch holes, and cover this bottom with sailcloth or blanket. Then pack in the charcoal regularly and very tightly with a wooden pestle. Great attention should be given to this part of the operation, in order to prevent the occurrence of holes or crevices in the charcoal during the process of filtration. Pack the sides of the tub thoroughly. Cover the charcoal with sailcloth, place laths over the cloth, and use heavy stones to keep the charcoal down.**

Perfumery.

The receipts in this department embrace a great variety of odorous essences, extracts, tinctures, oils, pomades, cosmetics, dentifrices, and other articles of the toilet, and are all derived from the latest and best authorities.

940. How to Prepare Essences and Perfumed Spirits. The scented spirits of **the perfumer are merely alcoholic solutions of the aromatic and odorous principles of the substances they represent, obtained in one or other of the following ways:—By simply adding essential oil or other odoriferous matter to the spirit, and agitating them together until solution is complete. Occasionally the resulting alcoholic solution is distilled. By macerating or digesting the ingredients (previously bruised or pulverized) in the spirit, with frequent agitation, for a few days, when the resulting tincture is either decanted and filtered (if necessary), or the whole is thrown into a still, and submitted to distillation by a gentle heat. In the former case, the spirit retained in the pores of the solid ingredients, and which, consequently, cannot be drawn off, is obtained by powerful pressure.** (*See Nos.* 39 and 40.) **By digesting the spirit, with frequent agitation on highly scented pomade or oil, in a close vessel, at a gentle heat for some hours, and the next day decanting the perfumed spirit.** (*See No.* 40.) **Distillation is only applicable to substances of which the fragrant principles are volatile, and readily pass over with the spirit during the process. Thus, flowers, flowering tops, herbs, seeds, &c., may, in general, be so treated; but not musk, ambergris, vanilla, and a few other substances, of which the odor is of a more fixed nature.** (*See No.* 13.) **In proceeding by distillation, one of the first points to be attended to is, to see that the still, condensing-worm, or refrigerator, and the receiver, be perfectly clean and sweet, and absolutely free from the odor of any previous distillation. The lute employed to secure the still-head or capital to the still must also be of a simple character, incapable of conveying any taint to the hot vapor that comes in contact with it. (Linseed-meal or equal weights of linseed-meal and whiting, made into a stiff paste or dough with water, is a good lute for the purpose. Sweet almond-cake meal is still better.) The most convenient and manageable source of heat is high-pressure steam supplied from an adjacent boiler, the body of the still being enclosed in** a steam-jacket for the purpose. A water-bath, the boiling-point of which should be raised by the addition of about ¼ its weight of common salt, comes next in point of convenience and effect. When the still is exposed to the heat of a naked fire, or that of dry flues, a little water must be put into it along with the spirit and other ingredients, to prevent empyreuma; and the greatest care must be taken to stop the process, and to remove the receiver, as soon as the proper quantity of distillate is obtained. If this be neglected, the odor of the whole may be vitiated. Moderately rapid distillation is favorable to the odor of the product, as is also the elevation of the boiling-point in the liquid operated on. Spirit distilled from aromatics decreases in odor with the boiling-point of the ingredients in the still. To raise the latter, the addition of 1 to 1¼ pounds of common salt per gallon is often advantageously made. (*See Nos.* 5, 6 and 7.) By one or other of the above methods, or a combination of them, are, in general, prepared all the "eaux," "esprits," and "extraits," of the perfumers. As a rule, extraits and essences are preferred to eaux and esprits as the basis of good perfumery, when the color is not objectionable. Whatever process is adopted, the utmost care must be taken in the selection of the spirit used. Only spirit that is absolutely pure, flavorless, and scentless, must be employed, if we desire the product to be of fine quality. Malt-spirit or corn-spirit contaminated, even in the very slightest degree, with fusel-oil or corn-oil, or a whiskey-odor, is utterly unfit for the purpose. So also the refined methylated spirit now so commonly and fraudulently sold as spirit of wine. The extreme purity of the spirit employed by the French manufacturing perfumers —it being actually spirit of wine, and not merely so in name—is one of the reasons why their odoriferous spirits are so much superior to those of the American houses. Great care must also be taken in the selection of the essential oils intended to be employed in making perfumed spirits. These should be pure or genuine, and should be pale and recent, or of the last season's distillation. If they be old, or have been much exposed to the air, they will contain more or less resin, and their alcoholic solution will be defective in fragrance, and be liable to permanently stain delicate articles of clothing to which it may be applied. The strength of the spirit used for concentrated essences, as a rule, should not be less than 90 per cent., or of the specific gravity .8332. A few require a spirit of even greater strength than this. The first quality of extraits, particularly those prepared from pomades and oils, and many of the eaux and esprits, also require 90 per cent. spirit. The strength of the spirit for the others, and for second qualities (commonly sold as the best in the stores), must be fully 75 per cent., or of the specific gravity .8765; that of the third quality fully 70 per cent., or specific gravity .8892; and that of the fourth quality fully proof, or specific gravity .920. The last is the lowest quality, and the weakest of any kind made by respectable perfumers; but the double distilled lavender-water, eau de Cologne, and other scents, vended in little showy bottles, by the druggists, and in fancy-stores, are commonly even much weaker than this, being often under proof. (*See No.* 1435.) The capacity of spirit, at this strength, of dissolving essential oil and other odorous matter is, however, very little. The solvent power of spirit decreases with its strength, but much more rapidly. (*Cooley.*)

941. Essences. The term *essence* is generally very loosely applied to a preparation of almost any kind, that is supposed to contain in a high degree the essential or distinctive principle or quality of some substance. Thus, the essential or volatile oils obtained from vegetable substances by distillation; concentrated infusions, decoctions, aqueous solutions, and tinctures, are all often erroneously termed essences.

In perfumery the word "essence" is applied only to a solution of an essential oil in deodorized alcohol, in the proportion, usually, of 2 drachms to 2 ounces of the essential oil to 1 quart of rectified spirits. Sometimes an essence, using the term in its correct sense, is distilled, with the addition of a little water; it is then called *distilled aromatic spirits.*

942. Essences of Flowers. The essences of those flowers which are not separately given in this work, may be made by one or other of the following general formulæ. Take of essential oil (of the respective flowers), 1 ounce avoirdupois, and rectified spirit 90 per cent. 1 pint (Imperial); dissolve as directed for "Essence of Almonds." Or, take of the (respective) flowers, 3 to 5 pounds; proof spirit, 2 gallons; digest for a few days, and then draw over, by distillation, 1 gallon of essence. For those flowers that are not strongly fragrant, the product may be distilled a second and a third time, or even oftener, from fresh flowers, as noticed under "Essence of Roses." The products obtained by distillation are always colorless; and hence flowers rich in color may, in general, be advantageously so treated. The flowers should be selected when in their state of highest fragrance; and should be picked to pieces, or crushed or bruised, as their nature may indicate. With many, the last is facilitated by the addition of some clean sand or common salt. Or, proceed in the way described under "Essence of Tuberose." This applies to most of those flowers that contain little fragrant oil, and of which the odor is extremely delicate. A small quantity of some other odorous essence or volatile oil is commonly added to the simple essences of flowers, at will, to enrich or modify the fragrance, each manufacturer usually pursuing his own taste in the matter. In some cases, spirit is impregnated with a combination of essential oils and other odorous substances, so as to produce, artificially, an odor resembling or approaching that of the particular flowers after which the products are named; although there may be none of the respective flowers employed in their preparation. This is particularly the case with flowers of which the odorous principle is difficult or troublesome to extract, or which possess very little of it. So also of the essences of many flowers having strange or attractive names, and no true fragrance. Hence arises the almost endless variety of fragrant essences, esprits, and similar preparations, vended by the perfumers of the present day, numbers of which are mere artificial combinations of other perfumes. (*Cooley.*)

943. Essence of Almonds; Essence of Bitter Almonds; Essence of Peach-kernels; Almond Flavor. Take of essential oil of almonds, 1 fluid ounce; and rectified spirit (90 per cent.), 19 fluid ounces; mix, and agitate or shake them together until united.

944. Essence of Roses. Take of pure otto of roses 1½ drachms (Troy); and alcohol (96 per cent.) 1 pint (Imperial); mix, place the bottle in a vessel of warm water until its contents acquire the temperature of about 85° Fahr., then cork it close, and agitate it smartly until the whole is quite cold. Very fine.

945. Extra Essence of Roses. Take of petals of roses (fresh) 3 pounds avoirdupois; and rectified spirit (90 per cent.) 5 Imperial quarts; digest the petals (picked to pieces) in the spirit for 24 hours, then distill to dryness by the heat of a water-bath. Digest the distillate (product of distillation) on a fresh quantity of rose-petals, and re-distill, as before; and repeat the whole process of maceration and distillation a third, fourth, fifth, and sixth time, or oftener, the last time observing to conduct the distillation rapidly, and to draw over only 1 gallon, which is the essence. Delicately and delightfully fragrant. It improves by age. The product of each of the above receipts is very superior; but that of the last has a peculiar delicacy of flavor, which distinguishes it from those prepared from the *otto*. Some makers add to each pint of the former 20 or 30 drops each oil of bergamot and neroli, and 15 or 20 drops essence of musk; but the product of the last formula is scarcely improved by any addition, unless it be a very little neroli or essence d'ambrette, or both, as the case may indicate. The best rose leaves to use are those of the rosa centifolia (cabbage-rose, damask-rose), or rosa sempervirens (musk-rose), or mixtures of them.

946. Essence of Rondeletia; Extrait de Rondeletia. Various formulæ are current for this exquisite perfume, of which scarcely any produce an article approaching in excellence the proprietary one. The following is an exception: Take of oil of lavender (Mitcham), ¾ ounce avoirdupois; oil of cloves (finest), 5 drachms avoirdupois; oil of bergamot, 4 drachms; ½ drachm each of the finest essence of ambergris and musk; rectified spirit (strongest), ¾ Imperial pint; agitate them together until completely united. Some persons add ½ drachm of neroli, or of oil of verbena (Indian lemon-grass), with or without 10 or 12 drops of otto of roses. Very fine.

947. Curious Essence. Take of otto of roses 2 drachms; oil of rose-geranium, 1 drachm; essence of musk, 3 Imperial fluid drachms; essence of ambergris, 1 Imperial fluid drachm; rectified spirit (warm), 1 pint; mix, closely cork the bottle, and agitate frequently until cold. A powerful, durable, and very agreeable perfume.

948. Essence de Frangipane; Extrait de Frangipane; Frangipanni. Take of neroli, 2 Imperial fluid drachms; essence royale, 3 fluid drachms; civet (powdered), 10 grains avoirdupois; oil of lavender, oil of cloves, oil of rhodium, of each, 5 or 6 drops; rectified spirit, 3½ to 4½ fluid ounces; digest a week, and then decant the clear portion. Powerful, durable, and pleasant.

949. Essence of Violets; Essence of Orris; Factitious. Take of Florentine orris-root (coarsely powdered), 1½ pounds avoirdupois; rectified spirit, 1 Imperial quart; proceed by percolation or the method of displacement, so as to obtain 1 quart of essence; or by digestion for two weeks, followed by powerful pressure in a tincture-press. The former is the best and most economical method. This forms the best essence of violets of the wholesale druggists. It may be, but is rarely, distilled. (*See No.* 954.)

950. Essence of Cologne; Cologne-Essence; Concentrated Eau de Cologne. This is prepared from the same odorous ingredients as "Eau de Cologne," but taking 7 or 8 times the quantity, and using alcohol or the strongest rectified spirit, without which a permanent solution of the whole of them cannot be formed. Used as a condensed and convenient substitute for ordinary "Eau de Cologne" by travelers, being less bulky. It is also kept in stock by druggists and perfumers, to enable them to prepare that article extemporaneously, by simply diluting it with 8 times its bulk of spirit of the appropriate strength.

951. Essence of Orange; Essence of Orange-peel. Oil of orange-peel is popularly so called. The alcoholic essence is made from this oil like essence of almonds. (*See No.* 943.)

952. Essence of Pimento; Essence of Allspice. Prepared from oil of pimento, as essence of almonds. Sometimes used in compound perfumes and cosmetics, and for toothache; but chiefly as a flavoring essence.

953. Essence of Pineapple. From pineapple oil (butyric ether), as the last. Sometimes taken on sugar, by smokers; but chiefly used by confectioners, liqueur manufacturers, &c. (*See No.* 1060.)

954. Essence of Tuberose. The flowers are placed in alternate layers with sheep's or cotton wool impregnated with the purest oil of ben or of olives, in an earthen vessel, closely covered, and kept for 12 hours in a water bath; the flowers are then removed and fresh ones substituted, and this is repeated until the oil is sufficiently scented. The wool or cotton is then mixed with the purest spirit of wine, and distilled in a water bath; or, it is first digested in a well closed vessel for several days in a warm situation, with frequent agitation. A similar plan is followed for the preparation of the essences of jasmine, violets, &c. (*See No.* 1349.)

955. Essence of Lemons. From oil of lemon, as essence of almonds. (*See No.* 943.) For this purpose the oil should have been recently expressed, and preserved from the air. A dash of essence of musk improves it as a perfume, but not as a flavoring essence. Oil of lemon is popularly called essence of lemons.

956. Concentrated Essence of Musk. Take of grain-musk (Tonquin or Chinese), 1 ounce avoirdupois; boiling distilled water, ¼ Imperial pint; digest them together in a close vessel, with frequent agitation, until quite cold, then add 3¼ pints rectified spirit (95 per cent.), ½ fluid ounce liquor of ammonia (.880-.885 specific gravity), and, having closely corked or stopped the vessel and securely tied it over with bladder, digest the whole for 1 or 2 months, with frequent agitation, in a room exposed to the sun, in summer, or in an equally warm situation in winter. Lastly, after repose, decant the clear portion, and, if necessary, filter it. A little essence of ambergris is commonly added to the filtrate, or, when this is not done, 1 to 2 drachms of ambergris are put into the vessel before closing it, and after adding the spirit. Very fine. The residuum is treated with fresh spirit for an inferior quality.

957. Fine Essence of Musk. Take ½ ounce finest grain-musk, civet and ambergris each 1 drachm, strongest essence d'ambrette, ½ pint. Instead of the ambergris, 1 to 1½ fluid ounces of essence of ambergris may be added after decantation. The quantity of civet ordered should on no account be exceeded. This produces the finest quality of the Paris houses.

958. Common Essence of Musk. Take ¾ ounce (avoirdupois) grain-musk, 1 quart (Imperial) rectified spirit (95 per cent.), and 2 fluid ounces finest essence of ambergris; digest, &c., as before. Excellent; but greatly inferior to the others. Essence of musk is an agreeable and powerful perfume, and is greatly esteemed in the fashionable world. Its odor is so durable that articles scented with it will retain the fragrance for years. The product of each of the above is of very fine quality; but that of No. 957 is the very finest that is made, and such as is seldom sold, except by the high-class perfumers, who obtain for it a very high price. It is powerfully and deliciously fragrant.

959. Best Way to Prepare the Essence of Musk and Ambergris. The best vessel for preparing essence of musk, as well as of ambergris, is a strong tin-bottle with a nicely rounded mouth and neck. Great care should be taken to cork it perfectly close, and, after this is done, to tie it over securely with wet bladder. The bottle should not be set in the full sunshine, but only in a position warmed by it; and in no case should the digestion be of shorter duration than three or four weeks, as otherwise much fragrant matter will escape solution. The addition of ⅛ to 1 fluid drachm, per pint, of liquor of ammonia, or of liquor of potassa (the first is greatly preferable), increases the solvent power of the spirit and vastly increases the fragrance of the essence. A few grains of salt of tartar (carbonate of potash) are sometimes added with the same intention; but this addition is objectionable, as it does not effect the object in view, whilst it occasions partial decomposition of the mixture. To facilitate the action of the menstruum, and to make the most of the ingredients, it is best to rub down the musk, &c., with a little powdered glass, sand, or lump sugar, as noticed under "Essence of Ambergris." Filtration and exposure to the air should, if possible, be avoided.

960. Essence Royale. Take of ambergris, 40 grains avoirdupois; grain-musk (pure), 20 grains; civet and carbonate of potassa, of each 10 grains; oil of cinnamon, 6 drops; oil of rhodium and otto of roses, of each 4 drops; rectified spirit, 4 Imperial fluid ounces; digest, with agitation, for 10 or 12 days, or longer. Very fragrant. The above is a celebrated receipt, but we think it would be improved by substituting 12 drops liquor of ammonia for the carbonate of potassa. (*See last receipt.*)

961. Essence of Neroli; Essence of Orange Blossoms; or Essence de Fleurs d'Oranges. Dissolve ½ ounce avoirdupois pure neroli in rectified spirit, 1 Imperial pint. An ounce of essence of jasmine, jonquille, or violets, is often added. A delicate and delicious perfume.

962. Essence of Storax (or Styrax); Extract of Storax. Take 1 ounce avoirdupois finest genuine liquid storax and ½ Imperial pint rectified spirit; digest, with agitation, for a week, and then decant the clear portion.

963. Essence of Ambergris; or Concentrated Tincture of Ambergris. Take 10 drachms avoirdupois 95 per cent. ambergris and 1 Imperial pint rectified spirit, put them into a strong bottle or tin can, secure the mouth perfectly and very firmly, and keep the vessel in a room exposed to the heat of the sun, or equally warm, for a month or two, observing to briskly agitate it daily during the whole time. Lastly, after repose, decant the clear portion, and, if necessary, filter it rapidly through soft blotting paper. Very fine. It forms the strongest and finest simple essence of ambergris of the Paris houses. (*See No.* 959.) The common practice in making the essence is to cut the ambergris up small before digesting it; but a much better plan is to rub down the ambergris with a sufficient quantity of powdered glass, clean silicious sand, or dry lump-sugar, observing afterwards to rinse the mortar out well two or three times, with portions of the spirit, so that nothing may be lost. A second quality may be made by employing half the quantity of ambergris to the same amount of spirit.

964. Essence of Ambergris. Ambergris 10 drachms avoirdupois; grain musk (Tonquin or Chinese pure), 3 drachms; rectified spirit, 1 quart. Proceed as in the last receipt. The products of the above two receipts form a delightful perfume highly esteemed in the fashionable world. A very small quantity of any one of them added to eau de Cologne, lavender-water, tooth-powder, hair-powder, pomades, wash-balls, &c., communicates a delicious fragrance. A few drops added to sweet-scented spirits, liqueurs, wines, &c., improve their flavor and aroma. 1 or 1½ fluid drachms added to a hogshead of claret, imparts a flavor and bouquet to the wine which is regarded by many as delicious.

965. Fine Essence of Vanilla. Take ½ pound avoirdupois finest vanilla, and rectified spirit, 1 Imperial quart; proceed as for essence of musk. (*See No.* 959.) Lastly, press and decant or filter. Very superior. It forms the best quality vended by the wholesale druggists, and is sold at exorbitant prices. This, as well as the preceding, is chiefly used for flavoring, and as an ingredient in compound perfumes and cosmetics. Essence of vanilla is a favorite and useful addition to tooth-cosmetics, pomades, &c. In preparing it, the vanilla, &c., should be cut small with a sharp knife; or what is better, rubbed down with a little powdered glass, sand, or lump-sugar.

966. Essence of Patchouli; Essence de Patchoulie; or Essence de Pouchapat. Take 3 pounds avoirdupois Indian patchouli (leaves or foliaceous tops), and rectified spirit 9 Imperial pints; digest for a week in a close vessel, add ¼ ounce oil of lavender (Mitcham) and promote solution by agitation. Next throw the whole into a still, and further add 1 gallon water and 2 or 3 pounds common salt. Agitate the whole briskly together, lute on the still-head, and distill over (rapidly) 1 gallon. To the distillate add ½ fluid ounce finest essence of musk; and after 10 days' repose, bottle it. A very fashionable perfume, particularly for personal use.

967. Common Essence of Patchouli. 1¼ ounces otto of patchouli, ½ ounce otto of rose, and 1 gallon rectified spirit.

968. Essence d'Ambrette; or Essence of Musk-seed. Take 1½ pounds avoirdupois finest musk-seed; grind it in a clean pepper-mill, and digest it for 3 or 4 weeks in 3 pints Imperial rectified spirit; the vessel being closely stopped or corked, and kept in a warm room all the time. Lastly decant, press and filter.

969. Essence of Bergamot. The popular name of oil of bergamot. A spirituous essence may be made in a similar way to that of almonds. (*See No.* 943.)

970. Essence of Cassia. From oil of cassia, as essence of almonds. (*See No.* 943.) Uses, &c., the same.

971. Essence of Cinnamon. From oil of cinnamon, as essence of almonds. (*See No.* 943.) Essence of cassia is commonly and fraudulently sold for it.

972. Essence of Civet. Take 1 ounce (avoirdupois) civet cut very small, and 1 pint (Imperial) rectified spirit; proceed as for essence of ambergris or musk. Its odor is only agreeable when faint and combined with that of other substances, which it sustains and increases. It is hence seldom or never used alone.

973. Essence of Lavender. Take 1 ounce avoirdupois oil of lavender (Mitcham) and ½ Imperial pint strongest rectified spirit; mix with agitation; a few drops of the essences of musk and ambergris being added at will. Very fine.

974. To Extract the Essence from any Flower. Take any flowers you choose; place a layer in a clean earthen pot, and over them a layer of fine salt. Repeat the process until the pot is filled, cover closely, and place in the cellar. Forty days afterwards, strain the essence from the whole through a crape by pressure. Put the essence thus expressed in a clear bottle, and expose for six weeks in the rays of the sun and evening dew to purify. One drop of this essence will communicate its odor to a pint of water.

975. To Make Attar, or Otto of Roses. Gather the flowers of the hundred-leaved rose (*rosa centifolia*), put them in a large jar or cask, with just sufficient water to cover them, then put the vessel to stand in the sun, and in about a week afterwards the attar—a butyraceous oil—will form a scum on the surface, which should be removed by the aid of a piece of cotton.

Cologne Water and Perfumed Spirits. In preparing eau de Cologne, it is essential that the spirit be of the purest description, both tasteless and scentless, and that the oils be not only genuine, but recently distilled; as old oils, especially if they have been exposed to the air, are less odorous, and contain a considerable quantity of resin and camphor, which would prove injurious. French spirit of 90 per cent. should be used in the manufacture of eau de Cologne, and when a weaker spirit is employed, the essential oils must be dissolved in a small quantity of 90 or 95 per cent. spirit. Should the mixture afterwards prove turbid, filter it through paper with a little carbonate of magnesia. (*See Nos.* 1080 and 1081.) To produce an article of the finest quality, distillation should be had recourse to; but a very excellent eau de Cologne may be produced by simple solution or maceration of the ingredients in the spirit, provided all the essences be new, pale-colored, and pure.

The mass of the eau de Cologne prepared in America, some of which possesses the most delicate fragrance, and is nearly equal to the best imported, is made without distillation.

977. Piesse's Best Quality Eau de Cologne. Mix with agitation 3 ounces attar of neroli pétale; 1 ounce attar of neroli bigarade; 2 ounces attar of rosemary; 5 ounces attar of orange zest; 5 ounces attar of citron zest; and 2 ounces attar of bergamot, with 6 gallons 95 per cent. grape spirit. Let it stand perfectly quiet for a few days. Although very fine eau de Cologne is often made by merely mixing the ingredients, it is better first to mix all the citrine attars with spirit, then distill the mixture, and afterwards add the rosemary and nerolies. This method is adopted by the most popular house in Cologne.

978. Eau de Cologne. To 3 pints alcohol of 95° add 12½ drachms oil of lemon, 1½ drachms oil of orange, 2½ drachms oil of cedrat, 1¼ drachms oil of vervain, 2½ drachms oil of bergamot, 2½ drachms oil of mint, 5 drachms oil of lavender, 1¼ drachms oil of white thyme, 2 drachms oil of Portugal, 1¼ drachms oil of rosemary, 8 ounces tincture of ambretta, and 1 pound eau de melisse; (*eau des carmes*); mix well in a bottle, and after standing six hours add 2½ drachms tincture of ambergris; then filter until clear. This is greatly improved by distilling.

979. Eau de Cologne—*Extra*.—Put 1 quart 95 per cent. alcohol into a bottle; add to it 9 drachms oil of cedrat, 2 drachms oil of thyme, 6 drachms each oil of bergamot and oil of lemon, 4 drachms oil of Portugal, 2 drachms each oil of neroli, oil of vervain and oil of rosemary, 2½ drachms oil of mint, 2 pints eau de melisse and 24 drops tincture of musk; mix thoroughly, and after standing for 12 hours, filter till clear.

980. Durockereau's Cologne Water. To 7 quarts French tasteless alcohol, add 11 drachms essence of Portugal, 13 drachms essence of bergamot, 1 ounce essence of lemon, 10 drachms essence of neroli, 1 ounce essence of rosemary, 1 ounce essence of lavender, 14 drachms rose water, 13 drachms jasmin water, 15 drachms orange-flower water. Mix the whole together, let it stand 24 hours, and distill over a water-bath.

981. Gouffe's Eau de Cologne. Take ½ ounce each essences of lemon, bergamot, and citron; ¼ ounce essence of rosemary; ½ ounce essence of neroli. Infuse for 8 days in 1 quart 95 per cent. alcohol. Filter, and bottle for use.

982. Farina's Eau de Cologne. Take of angelica-root, 10 grains; camphor, 15 grains; cassia-lignea, cloves, mace, nutmegs, wormwood tops, of each 20 grains; calamus aromaticus, sage, thyme, of each ½ drachm (Troy); orange flowers, 1 drachm (Troy); lavender flowers, 1½ drachms (Troy); rose petals, violets of each, 3 drachms (Troy); balm-mint and spear-mint of each 1 ounce (Troy); 2 sliced lemons; 2 sliced oranges, and 5 gallons rectified Cologne spirits. Bruise or slice the solids, and digest them in the spirit, with frequent agitation, for 2 or 3 days, then distill off 3 gallons. To this add, of oil of bergamot, *essential* oil of jasmin, 1 fluid ounce each; oil of balm-mint, oil of cedrat, oil of lavender, oil of lemon, 1 fluid drachm each; pure neroli and oil of anthos-seed, of each 20 drops. Agitate until solution is complete, and the next day, if necessary, filter. This formula, many years since, was confidentially given by the celebrated original Jean Maria Farina, who lived opposite the Jülichs Platz, in Cologne, to a professional gentleman, now deceased, with a solemn assurance that it was the one used by the former in his laboratory. After keeping the secret some years, this gentleman disclosed it. It seems unnecessarily complicated. Some of the articles, as the herbs wormwood and mint, are either useless or better omitted. The version given above differs from the original simply in being intended for only 5 gallons instead of twelve times the quantity. Dr. Cooley says he personally tried it, and found the quality of the product splendid.

983. Parrish's Best Cologne Water. Mix together 2 fluid ounces oil of bergamot, 2 fluid drachms oil of neroli, ½ fluid ounce oil of jasmin, 2 fluid drachms oil of garden lavender, 1 minim oil of cinnamon, 3 fluid ounces benzoated tincture, ½ fluid ounce oil of musk, 1 gallon deodorized alcohol, and 2 pints rose-water. The mixture should stand a long time before filtering for use.

984. Parrish's Common Cologne Water. A much cheaper preparation than the foregoing can be made by mixing 1½ fluid ounces oil of lavender, ½ fluid ounce oil of rosemary, 1 fluid ounce oil of lemon, and 20 drops oil of cinnamon, with 1 gallon alcohol.

985. Genuine Cologne Water. The following formula was published by one of the Farinas in the journal of the North German Apothecaries' Association. Dissolve 2 ounces by weight purified benzoin, 4 ounces oil of lavender, and 2 ounces oil of rosemary, in 9 gallons 95 per cent. fine Cologne spirits. To this solution add successively, 10⅔ ounces each of the oils of neroli, neroli petit-grain, and lemon; 20⅔ ounces each of the oils of sweet orange peel, limes, and bergamot; together with tincture of rose-geranium flowers, sufficient to suit the taste. Macerate for some weeks, then fill into flasks.

986. Fine Cologne Water. Take of pure 95 per cent. Cologne spirits, 6 gallons; oil of neroli, 4 ounces; oil of rosemary, 2 ounces; oil of orange, 5 ounces; oil of citron, 5 ounces; oil of bergamot, 2 ounces; mix with agitation; then allow it to stand for a few days perfectly quiet before bottling.

987. Cologne Water, Second Quality. Pure 95 per cent. alcohol, 6 gallons; oil of neroli, 2½ ounces; oil of rosemary, 2 ounces; oil of orange peel, 4 ounces; oil of lemon, 4 ounces; oil of bergamot, 4 ounces. Treat in the same way as the last.

988. Eau des Carmes; Eau de Melisse; Compound Spirit of Balm. Fresh flowering balm, 24 ounces; yellow rind of lemon, cut fine, 4 ounces; cinnamon, cloves, and nutmeg (bruised), of each 2 ounces; coriander seed (bruised), 1 ounce; dried angelica root, 1 ounce; rectified spirit, 1 gallon. Macerate for 4 days, and distill in a water-bath.

989. Fine Lavender Water; or Eau de Lavande. Take 2 ounces (avoirdupois) finest oil of lavender (Mitcham), essence of musk (finest), 1 Imperial fluid ounce; essence of ambergris (finest), and oil of bergamot (recent), of each ½ ounce; rectified spirit (90 per cent., scentless), ½ gallon; mix by agitation. Very fine without distillation; but better for it, in which case the essences should be added to the distillate. Delightfully and powerfully fragrant. (*Cooley.*)

990. Smith's Lavender Water. Take ½ ounce (avoirdupois) oil of lavender (Mitcham); essence of ambergris, ½ ounce; eau de Cologne (finest), ½ Imperial pint; rectified spirit, ½ pint; mix by agitation. Very fragrant, and much esteemed. The ordinary lavender water is usually made with spirit at proof, or even much weaker; hence its inferior quality to that of the higher class of perfumers. 1 ounce of true English oil of lavender is all that will perfectly combine with 1 gallon of proof spirit (or 1 drachm to the pint); any excess rendering it milky or cloudy.

991. Common Lavender Water. English oil of lavender, 3 ounces; rectified spirit (90 per cent.), 1 gallon. Dissolve. Cordial, and fragrant.

992. Eau de Bouquet. Take of spirit of rosemary, essence of violets, and orange-flower water, of each 1 Imperial fluid ounce; oil of bergamot and oil of jasmin, of each 1 fluid drachm; oil of lavender and oil of verbena, of each ½ fluid drachm; eau de rose, ½ pint; rectified spirit, 1½ pints; mix. A delightful perfume. Various other similar formulæ are employed.

993. Eau de Maréchale. Take of essence of violets, 1 Imperial fluid ounce; oil of bergamot and oil of cloves, of each ¼ ounce (avoirdupois); orange-flower water, ½ pint; rectified spirit, 1 pint; mix. An agreeable and favorite perfume.

994. Eau d'Ambre Royale; Eau Royale. Take of essence of ambergris and essence of musk, of each 1 Imperial fluid drachm; eau d'Ambrette and eau de fleurs d'oranges, of each 2½ fluid ounces; rectified spirit, 5 fluid ounces; mix. Very agreeable and durable.

995. Eau d'Ambrette; or Esprit d'Ambrette. Take 1 pound (avoirdupois) grains d'Ambrette (musk-mallow seed, bruised); rectified spirit, 1 Imperial quart; water, ½ pint; digest for 7 or 8 days, and distill off 1 quart. Very fine. Commonly sold as "Essence d'Ambrette." When used alone, a very few drops of essence of ambergris and esprit de rose improve it.

996. Fine Hungary Water. Take 2 pounds (avoirdupois) rosemary-tops (in blossom); ½ pound sage (fresh); rectified spirit, 3 Imperial quarts; water, 1 quart; digest for 10 days, throw the whole into a still, add 1½ pounds common salt, and draw over 6 pints. To the distillate add 1 ounce bruised Jamaica ginger, digest a few days, and either decant or filter. The old plan of adding the ginger before distillation is wrong, as the aromatic principle of the root does not pass over with the vapor of alcohol.

997. Common Hungary Water. Take 1½ to 2 Imperial fluid drachms pure oil of rosemary; oil of lavender (English), ½ fluid drachm; orange-flower water ½ pint; rectified spirits, 1½ pints; mix. No. 996 is the genuine formula. This is the perfume usually sold by the perfumers. Spirit of rosemary is now commonly sold for it by the druggists.

998. Simple Perfumed Spirits—Esprits. The simple perfumed spirits (esprits) and odoriferous tinctures are principally used in making compound eaux, esprits, &c. Their common strength, per pint, is, of—

Attar of roses, ¼ fluid drachm; neroli, essence de petit grain, of each 1½ to 2 fluid drachms; essential oils (ordinary), ½ fluid ounce; concentrated essences, 2 to 2½ fluid ounces. The spirit of wine employed for them should in no case be weaker than 75 per cent., and for spirit of roses (esprit de rose), it should be, at the least, 90, or else little of the attar will be dissolved. These proportions may be adopted for all the simple spirits of the perfumer for which separate formulæ are not given in this work, and even in place of those so given, at the convenience of the operator, when intended for the use just mentioned. When flowers, leaves, seeds, &c., are employed, the proportions may be 1½ to 3, or even 5 pounds to the gallon of the distillate or product, according to their nature; and, with certain flowers, the process must be repeated with fresh flowers, as often as necessary. To mature and bring out the full fragrance of distilled spirits, they should be kept for some time in a cellar, or other cool situation, previously to being used or offered for sale. The same applies, though in a less degree, to perfumed spirits prepared by the other methods.

999. Esprit de Bergamotte. Take 5 Imperial fluid drachms oil of bergamot (finest, recent); oil of rose-geranium and oil of verbena, each ½ fluid drachm; essence of ambergris, 2 fluid drachms; essence of musk, ½ fluid drachm; rectified spirit, 1 pint; mix.

Very fine. For a second quality (usually called best), 1 quart of spirit (70 per cent.) is used; for a third quality, 3 to 4 pints at proof.

1000. Eau de Lavande de Millefleurs. Take 1 quart eau de lavande; oil of cloves, 1¼ fluid drachms; oil of cassia and essence of ambergris, each ½ fluid drachm; mix.

1001. Esprit de Rose. The compound perfume sold under this name is commonly made as follows: Take 1 Imperial pint finest simple esprit de rose (*see No.* 998); essence of ambergris and oil of rose-geranium, each ½ fluid drachm; mix. Delicately fragrant.

1002. Esprit de Bouquet. Take 4 Imperial fluid drachms oil of lavender; oil of bergamot and oil of cloves, each 1½ fluid drachms; essence of musk and oil of verbena, each ½ fluid drachm; attar of roses, 5 to 6 drops; and rectified spirit, 1 pint; mix, and agitate frequently for a day or two. A very powerful and agreeable scent.

1003. Eau d'Héliotrope. Take essence of ambergris, coarsely powdered, ¼ Imperial fluid drachm; vanilla, ¼ ounce avoirdupois; orange-flower water, ½ pint; rectified spirit, 1 quart; digest for a week, and then decant or filter. 5 or 6 drops each of oil of bitter almonds and cassia are sometimes added. Used both as a cosmetic and perfume.

1004. Esprit de Jasmin Odorant. Take extrait de jasmin, and rectified spirit, each ½ Imperial pint; essence of ambergris, ½ fluid drachm; neroli (finest), 8 or 10 drops; mix. A delicate and favorite foreign scent.

1005. Millefleur Water. Very pure rectified spirit, 9 pints; balsam of Peru (genuine) and essence of cloves, each 1 ounce; essences of bergamot and musk, each 2 ounces; essences of neroli and thyme, each ½ ounce; eau de fleurs d'oranges, 1 quart; mix well. Very fine.

1006. Honey Water (Eau de Miel). Rectified spirit, 8 pints (Imperial); oil of cloves, oil of lavender, oil of bergamot, of each ¼ ounce avoirdupois; musk, 15 grains; yellow-sanders shavings, 4 ounces; digest for 8 days, and add 2 pints each of orange-flower and rose waters.

1007. Honey Water. (With Honey.) White honey, 8 ounces avoirdupois; coriander seed, 8 ounces; fresh lemon-peel, 1 ounce; cloves, ¼ ounce; nutmeg, benzoin, styrax calamita, of each 1 ounce; rose and orange-flower water, of each 4 ounces; rectified spirit, 3 Imperial pints; digest for a few days, and filter. Some receipts add 3 drachms of vanilla, and direct only ½ ounce of nutmeg, storax, and benzoin.

1008. Rose Water. The ordinary best rose-water of the stores, particularly of the wholesale druggists who deal largely in the article, is generally made as follows:—Dissolve attar of roses, 6 drachms avoirdupois, in strongest rectified spirit (hot), 1 Imperial pint; throw the solution into a 12-gallon carboy, and add 10 gallons pure distilled water, at 180° to 185° Fahr.; at once cork the carboy (at first loosely), and agitate the whole briskly (at first cautiously), until quite cold. The product is really superior to much of the trash carelessly distilled from a scanty quantity of rose-leaves, and sold as rose water. (*See Nos.* 1071 and 1079).

1009. Orange-Flower Water. The genuine imported article is one of the most delightfully fragrant of all the odoriferous distilled waters. An imitation may be made as follows:—Take of orange-flowers, 7 pounds avoirdupois; fresh thin yellow-peel of bitter oranges, 6 to 8 ounces; water, 2 Imperial gallons; macerate 24 hours, and then distill 1 gallon.

1010. Orange-Flower Water. Another method is as follows.—Orange-flowers, 12 pounds avoirdupois; water, 35 pounds; distill 24 pounds for double orange-flower water; this, with an equal quantity of distilled water, forms the single. The flowers should not be put into the still till the water nearly boils.

1011. Florida Water. Dissolve in ½ gallon 90 per cent. alcohol, 1 ounce each oil of lavender, oil of bergamot, and oil of lemon; and of oil of cloves and cinnamon 1 drachm each; add 1 gallon water, and filter.

1012. Florida Water. Oil of bergamot, 3 ounces; oil of cinnamon, 4 drachms; tincture of benzoin, 2 ounces; 75 per cent. alcohol, 1 gallon. Mix and filter. (*See No.* 976.)

1013. Fine Florida Water. Take 2 drachms each of the oils of lavender, bergamot, and lemon; 1 drachm each of tincture of turmeric and oil of neroli; 30 drops oil of balm and 10 drops oil of rose; mix the above with 2 pints deodorized alcohol. (*See No.* 976.)

1014. Tincture of Coriander. Powder coarsely 4 ounces coriander seed, and macerate for 15 days in 1 pint 95° alcohol; strain and filter.

1015. Tincture of Nutmegs. Bruise well 6 ounces nutmegs in 1½ pints 95° alcohol; let it remain for a couple of weeks, stirring occasionally; then press through a coarse cloth, and filter. Tincture of ginger, mace, and other spices are prepared by the same method.

1016. Tincture of Storax. Macerate 5 ounces storax in 3 pints 95° alcohol, until dissolved, then filter.

1017. Alcoholate of Roses. Macerate 2 pounds fresh roses in 2 quarts alcohol of 95° and 1 pint water for 12 hours; then distill by means of a water-bath. If a superior article is required, the alcoholate thus prepared may be used to macerate 2 pounds more roses, and then distilled as before.

1018. Tincture of Vanilla. Steep 2 ounces vanilla, cut into small pieces, in 1 pint alcohol, for about a month; stir frequently, and filter.

1019. Tincture of Benzoin. In 2½ quarts alcohol of 95°, macerate 8 ounces powdered benzoin until dissolved, then filter it and bottle; cork closely.

1020. Tincture of Balsam of Peru. Macerate 8 ounces liquid balsam of Peru in 3 pints 95° alcohol; when dissolved, filter.

1021. Tincture of Grain of Paradise. Macerate 4 ounces coarsely powdered grain of paradise for 15 days in 1 pint alcohol of 95°, then press through a cloth and filter.

1022. Tincture of Balsam of Tolu. Dissolve 5 ounces balsam of Tolu in 3 pints alcohol, and filter.

1023. Tincture of Cardamoms. Bruise 4 ounces cardamoms, and macerate 2 weeks in alcohol of 95°; press through a cloth and filter.

1024. Tincture of Ambergris. Powder thoroughly 1 ounce ambergris and ½ ounce sugar in a warm mortar; then dissolve ½ ounce carbonate of potash in 14 ounces alcoholate of roses, and add to it 3½ ounces tincture of musk (*see No.* 1025); macerate the whole for about 1 month, and filter.

1025. Tincture of Musk. Rub ½ ounce musk in a warm mortar with a little sugar; macerate for a month in 7 ounces alcohol containing 1 ounce each tincture of ambergris and tincture of vanilla. Filter thoroughly and then add a few drops of attar of roses.

1026. Economical Perfumes. The cheap perfumes which are offered for sale in small fancy bottles, are of the simplest kind, and from the nature of the case, made of the least expensive materials. The following are the leading mixtures, which are sold under the names deemed the most likely to prove attractive:

Mix 1 ounce essence of bergamot, or attar of santal, with 1 pint spirits of wine.

Mix ½ ounce each of the attars of lavender and bergamot, and 1 drachm attar of cloves, with 1 pint spirit of wine.

Mix ¼ ounce attar of lemon grass, and ½ ounce essence of lemons, with 1 pint spirit of wine.

Mix ¼ ounce attar of petit-grain, and ½ ounce attar of orange peel, with 1 pint spirits of wine.

These mixtures are filtered through blotting paper with the addition of a little magnesia to make them bright. It would be well if all the cheap perfumes put up in attractive bottles were as good as these mixtures. A large proportion of them are far inferior, and frequently little more than weak perfumed waters.

1027. To Make Imitation Bay Rum. The genuine bay rum is made by digesting the leaves of the Bay plant (an aromatic plant which grows in the West Indies), in rum, and subsequent distillation. The imitation is prepared from the essential oil obtained from the Bay plant. Mix 1 ounce of oil of Bay (or ¾ ounce oil of Bay, and ¼ ounce of either oil of pimento, allspice, or cloves), with 4 gallons 95 per cent. alcohol; then add gradually 4 gallons of water, shaking the mixture constantly. If the mixture should become milky, the addition of a little alcohol will make it clear. Probably the best imitation is as follows: 10 fluid drachms oil of Bay, 1 fluid drachm oil of pimento, 2 fluid ounces acetic ether, 3 gallons alcohol, and 2½ gallons water. Mix, and after 2 weeks' repose, filter.

1028. West India Bay Rum. Take 2 pounds of leaves of the myrtus acris, ½ pound cardamoms, 2 ounces cassia, 1½ ounces cloves, and 9 quarts rum. Distill 1½ gallons. Bay rum may be colored with tincture of saffron, or with a mixture of equal parts caramel (*see No.* 694) and tincture of turmeric.

1029. Cheap Bay Rum. Saturate a ¼ pound block of carbonate of magnesia with oil of Bay; pulverize the magnesia, place it in a filter, and pour water through it until the desired quantity is obtained, then add alcohol. The quantity of water and of alcohol employed depends on the desired strength and quality of the Bay rum.

To Prepare Flavoring Extracts.

The following excellent receipts, taken from the "American Journal of Pharmacy," are by Prof. W. Procter, Jr.

1031. Lemon Extract. Expose 4 ounces of the exterior rind of lemons in the air until partially dry; then bruise in a wedgewood mortar; add to it 2 quarts deodorized alcohol of 95°, and agitate until the color is extracted; then add 6 ounces recent oil of lemon. If it does not become clear immediately, let it stand for a day or two, agitating occasionally. Then filter.

1032. Orange Extract. Follow the same method as for *lemon extract*, using 4 ounces exterior rind of oranges, 1 quart of deodorized alcohol of 95°, and 2 ounces recent oil of orange.

1033. Extract of Bitter Almonds. Mix together 4 ounces oil of bitter almonds, 1 ounce tincture of turmeric, and 1 quart 95° alcohol.

1034. To Neutralize the Poison in

Extract of Bitter Almonds. As this extract is poisonous in a quantity, it is better to deprive it of its hydrocyanic acid as follows:—Dissolve 2 ounces sulphate of iron in a pint of water; in another pint of water slake 1 ounce lime recently burned; mix them together, and shake the mixture with 4 ounces oil of bitter almonds. Distill in a glass retort until the whole of the oil has passed over; and after allowing the oil time to separate from the water, remove it for use.

1035. Extract of Rose. Bruise 2 ounces of hundred-leaved rose-leaves; make an extract from them by macerating in 1 quart deodorized alcohol; press the quart of alcohol out, and add to it 1 drachm oil of rose, and filter through paper. If there are no red rose leaves, a little tincture of cochineal will give a pale rose tint.

1036. Extract of Cinnamon. Dissolve 2 drachms oil of cinnamon in 1 pint deodorized alcohol; add gradually 1 pint of water, and then stir in by degrees 4 ounces powdered Ceylon cinnamon; agitate several hours, and filter through paper.

1037. Extract of Nutmegs. Mix 2 drachms oil of nutmegs with 1 ounce powdered mace; macerate for 12 hours in 1 quart deodorized alcohol, and filter.

1038. Extract of Ginger. Pack 4 ounces powdered ginger in a percolator, moisten it with a little alcohol, then pour on alcohol until 1½ pints of tincture have passed through. Mix this with 8 ounces syrup.

1039. Extract of Black Pepper. This is prepared from powdered pepper in the same manner as the extract of ginger, pouring on alcohol until a quart has passed through, and omitting the syrup.

1040. Extract of Capsicum. Prepared from powdered capsicum, in the same manner as black pepper.

1041. Extract of Coriander. Mix 4 ounces powdered coriander with 1 drachm oil of coriander; add the mixture to 1½ pints alcohol of 95°, and ½ pint water; macerate for 24 hours, decant the liquid; put the matter that has settled into a percolator, and pour on it the decanted liquid, adding alcohol until a quart has run through.

1042. Extract of Vanilla. Cut 1 ounce vanilla into small pieces, and triturate with 2 ounces sugar to a coarse powder; put it into a percolator, pour on it diluted alcohol until 1 pint has run through—then mix with 1 pint syrup.

1043. Extract of Celery. Bruise 2 ounces celery seeds, and put into a percolator; pour on 1 pint deodorized alcohol, then pour on water till a pint of extract has passed through; triturate with 1 drachm carbonate of magnesia, and filter.

1044. Extract of Soup-herbs. Put into a percolator 1 ounce each of thyme, sweet marjoram, sweet basil, and summer savory, and 1 drachm celery seeds. Pour on them sufficient diluted alcohol to make 1 pint of extract.

Artificial Fruit Essences.

These are composed chiefly of compound ethers, which possess the odor and flavor of certain fruits. In some of the following receipts, where tartaric, oxalic, succinic or benzoic acid enters into the composition of an essence, it must be understood that these acids are not to be used in their pure state, but in the form of saturated solutions (*see No.* 27) *in cold* alcohol. Glycerine will be found as an ingredient in nearly all these artificial essences; it seems to blend and harmonize the different odors.

1046. Peach Essence. This is a mixture of 5 parts glycerine, 2 parts aldehyde, 5 parts acetate of ethyl, 5 parts formiate of ethyl, 5 parts butyrate of ethyl, 5 parts valerianate of ethyl, 5 parts œnanthylate of ethyl, 1 part sebacic ether, and 2 parts salicylate of methyl.

1047. Apricot Essence. To 4 parts glycerine add 1 part chloroform, 10 parts butyrate of ethyl, 5 parts valerianate of ethyl, 1 part œnanthylate of ethyl, 2 parts salicylate of methyl, 1 part butyrate of amyl, and 1 part saturated solution of oxalic acid in alcohol. (*See No.* 1045.)

1048. Plum Essence. To 8 parts glycerine, add 5 parts of aldehyde, 5 parts acetate of ethyl, 1 part formiate of ethyl, 2 parts butyrate of ethyl, and 4 parts œnanthylate of ethyl.

1049. Cherry Essence. Take 3 parts glycerine, 5 parts acetate of ethyl, 5 parts benzoate of ethyl, 1 part œnanthylate of ethyl, and 1 part saturated solution (*see No.* 1045) of benzoic acid in alcohol.

1050. Black Cherry Essence. Mix 10 parts acetate of ethyl with 5 parts benzoate of ethyl, 2 parts œnanthylate of ethyl, 1 part saturated solution of oxalic acid, and 2 parts solution of benzoic acid. (*See No.* 1045.)

1051. Lemon Essence. To 5 parts glycerine, 1 part chloroform and 1 part nitric ether, add 2 parts aldehyde, 10 parts acetate of ethyl, 10 parts valerianate of amyl, 10 parts solution of tartaric acid, and 1 part saturated solution of succinic acid. (*See No.* 1045.)

1052. Pear Essence. To 10 parts glycerine add 5 parts acetate of ethyl and 10 parts acetate of amyl.

1053. Orange Essence. With 10 parts glycerine, mix 2 parts chloroform, 2 parts aldehyde, 5 parts acetate of ethyl, 1 part each of formiate, butyrate and benzoate of ethyl, 1 part salicylate of methyl, 10 parts acetate of amyl, 10 parts essence of orange, and 1 part saturated solution of tartaric acid. (*See No.* 1045.)

1054. Apple Essence. To 4 parts glycerine, 1 part chloroform, and 1 part of nitric ether, add 2 parts aldehyde, 1 part acetate of ethyl, 10 parts valerianate of amyl, and 1 part saturated solution of oxalic acid. (*See No.* 1045.)

1055. Grape Essence. To 10 parts glycerine and 2 parts chloroform, add 2 parts aldehyde, 2 parts formiate and 10 parts œnanthylate of ethyl, 1 part salicylate of methyl, and 5 parts tartaric and 3 parts succinic acids in saturated solution. (*See No.* 1045.)

1056. Gooseberry Essence. To 1 part aldehyde add 5 parts acetate, 1 part benzoate and 1 part œnanthylate of ethyl, and 5 parts saturated solution of tartaric, and 1 part each of the same of succinic and benzoic acids. (*See No.* 1045.)

1057. Raspberry Essence. To 4 parts glycerine and 1 part nitric ether, add 1 part aldehyde, 5 parts acetate of ethyl, and 1 part each of formiate, butyrate, benzoate and œnanthylate of ethyl, 1 part sebacic ether, 1 part salicylate of methyl, 1 part each acetate and butyrate of amyl, 5 parts tartaric and 1 part succinic acid in saturated solution. (*See No.* 1045.)

1058. Strawberry Essence. To 2 parts glycerine and 1 part nitric ether add 5 parts acetate, 1 part formiate and 5 parts butyrate of ethyl, 1 part salicylate of methyl, and 3 parts acetate and 2 parts butyrate of amyl.

1059. Melon Essence. Take 3 parts glycerine, 2 parts aldehyde, 1 part formiate, 4 parts butyrate and 5 parts valerianate of ethyl, and 10 parts sebacic ether.

1060. Pineapple Essence. To 3 parts glycerine and 1 part chloroform add 1 part aldehyde, 5 parts butyrate of ethyl and 10 parts butyrate of amyl.

Extraits; Extracts.

In French perfumery these are, appropriately, strong spirituous solutions, either simple or compound, of the essential oils and odorous principles of plants and other substances, obtained by infusion or digestion, as distinguished from those that are obtained by distillation and direct solution. Under the term, however, are often classed many perfumes prepared with rectified spirit by the latter methods, and which are highly charged with the fragrant matter, or matters, which they represent. The preparation of most of the extraits is simple enough, the chief care necessary being that the spirit be absolutely scentless and of sufficient strength, and that the oils and other materials be recent and perfectly pure.

1062. Extrait de Rondeletia. Take 12 drachms avoirdupois oil of lavender (Mitcham); oil of cloves, 5 drachms; oil of bergamot, 4 drachms; oil of verbena (or neroli), 1 drachm; essence of ambergris and essence of musk, of each ½ Imperial fluid drachm; rectified spirit (90 per cent.), 1 pint; mix. A rich and highly esteemed perfume.

1063. Extrait de Millefleurs. Take 4 grains finest grain musk; finest ambergris, 6 grains; oil of lemon, 6 drachms; oil of lavender (English), and oil of cloves, each 4 drachms; liquid storax (genuine), 1 drachm; oil of verbena, oil of pimento and neroli, of each 12 drops (minims); rectified spirit, 1 Imperial pint; macerate in a warm room, with frequent agitation, for 2 or 3 weeks. Very fine. The omission of the storax renders it paler, and thus preferable to some persons.

1064. Jockey Club Bouquet. Mix 1 pint extract of rose, 1 pint extract of tuberose, ½ pint extract of cassia, 4 ounces extract of jasmin, and 3 ounces tincture of civet. Filter the mixture.

1065. Bouquet de Millefleurs. Mix 1 pint extract of rose; ½ pint each of the extracts of tuberose, jasmin, orange-flower, cassia, and violet; 4 ounces essence of cedar, 2 ounces each of the tinctures of vanilla, ambergris, and musk; ½ pint essence of rose, 1 ounce attar of bergamot, and 10 drops each of the attars of almonds, neroli, and cloves. Let the mixture stand for a week, and then filter.

1066. Bouquet de Rondeletia. Mix 2 ounces attar of lavender, 1 ounce attar of cloves, 1 ounce attar of bergamot, 3 drachms attar of roses, 4 ounces each of the tinctures of musk, vanilla, and ambergris, with 1 gallon deodorized alcohol. After a month's repose, filter.

1067. Imitation Lily of the Valley. This much admired perfume is made by mixing together ½ pint extract of tuberose, 1 ounce extract of jasmin, 2 ounces extract of orange-flower, 3 ounces extract of vanilla, ¼ pint extract of cassia, ¼ pint extract of rose, and 3 drops attar of almonds. Keep this mixture for a month and then use.

1068. Imitation Essence of Myrtle. Mix together and allow to stand for 2 weeks, ½ pint extract of vanilla, 1 pint extract of roses, ½ pint extract of orange-flower, ½ pint extract of tuberose, and 2 ounces extract of jasmin.

1069. Extract of Patchouli. Mix 1¼ ounces attar of patchouli, and ½ ounce attar of rose, with 1 gallon rectified spirits.

Aromatic, Odoriferous, or Perfumed Waters, &c.

These are strictly pure water charged by distillation with the volatile, aromatic, and odorous principles of plants; or they are solutions of these principles, chiefly the essential oils, in distilled water. The simple fragrant waters of the perfumers are of the former kind; those of the wholesale druggists and of pharmacy belong to either class, according to the mode of their preparation.

1071. Proportions of Aromatics Submitted to Distillation for Making Perfumed Waters. The vegetable matter (bruised, if necessary), in the quantity ordered, is to be put into the still along with 2 gallons of pure water, but only 1 gallon drawn over. In this way the finest fragrant distilled waters may be produced from all flowers, and other aromatic vegetable substances. The points requisite to be attended to are, that the flowers be fresh, gathered after the sun has risen and the dew exhaled, and that sufficient water be used to prevent the flowers being burned, but not much more than is sufficient for this purpose. The quantities usually directed are: Roses, 8 pounds (avoirdupois); water, 2 gallons (Imperial); distill 1 gallon for *single*, and the same water with 8 pounds of fresh roses for *double* rose water. The usual quantities of aromatic material required in proportion to the amount of distilled water to be obtained, are given in classified form in the Journal de Pharmacie as follows: Fresh aromatic plants, such as wormwood, black-cherry, scurvy-grass, hyssop, cherry-laurel, lavender, balm, mint, peach-leaves, roses, and sage, require 1 part of the plant for each part distilled product desired. Fresh and dry aromatics, as bitter almonds, orange-flowers, melilot, horse-radish, elder, and tansy, require 1 part of the plant to 2 parts of distilled product. Dry and very aromatic plants, as angelica, green anise, juniper berries, camomile, canella, cascarilla, fennel, sassafras, linden-flowers, and valerian, require 1 part of the plant to each 4 parts of distillate. These proportions will be some guide both in respect of the distilled waters referred to, and others not included in the list. In general, druggists draw over 2 gallons of water from the respective quantities of flowers, herbs, bark, or seeds, ordered in the pharmacopœias, quantity rather than quality being their object. Manufacturing perfumers, on the contrary, either use an excess of flowers for their finer odoriferous waters, or they preserve only the first and stronger portion of the water that distills over; the remainder being separately collected and used for a second distillation with fresh flowers. In some cases, where a very superior quality is desired, they re-distill the water of the first distillation and preserve only the first ⅔, or even only the first half, that passes over.

1072. Elder-flower Water, Acacia-flower Water, and Bean-flower Water, are prepared in the same manner as rose water. (*See Nos.* 1071 *and* 1079.)

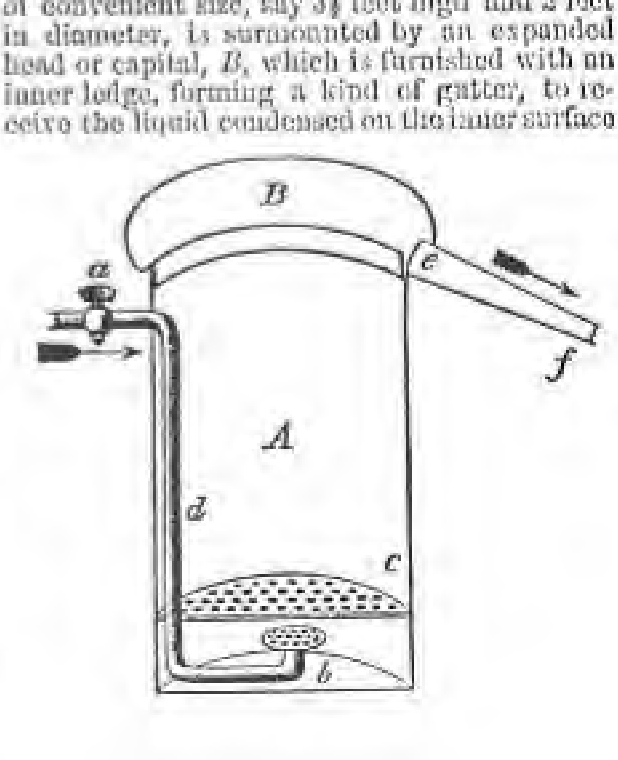
1073. Directions for Distilling Perfumed Waters. The following directions are, in the main, those given by the thoroughly practical chemist, Mr. Arnold J. Cooley. In the distillation of odoriferous waters, manufacturing perfumers employ their utmost care, in order to produce a highly fragrant article, free from any contamination that can vitiate the purity of their odor, or lessen their keeping qualities. The still may be of copper, but the head and worm should be formed of solid tin. It should be furnished with a high and narrow neck to prevent the liquor in it spirting over into the neck and condensing-worm. A still furnished with a steam-jacket is the most convenient for the purpose, as the heat of steam, or of a salt-water bath, can alone be safely employed. The common plan is to reject the first 2 or 3 fluid ounces that pass over, and to collect the remainder of the runnings until the proper quantity be obtained. The whole product is then agitated together, and stored, loosely covered, in a cool cellar for some weeks, or even months, in order that it may lose its herbaceous odor and the rawness from recent stillage. It is a common practice to separate any volatile oil floating on waters after distillation, but Mr. Haselden, of England, recommends the excess of oil to be well shaken with the water and the whole transferred to the stock vessel, where the oil will separate; it keeps better thus treated, and full strength is ensured. He prefers the stock vessel to be of stoneware, furnished with a tap about 2 inches from the bottom, whereby the water can be drawn out clear, the oil either rising to the top or sinking to the bottom, according to its specific gravity. As soon as it has acquired its full odor, or reached maturity, it is carefully decanted into bottles, which are then well corked or stopped, and stored in a moderately cool place. Some of the leading manufacturing perfumers keep a separate still for each of their more delicate distilled waters, and thoroughly clean them out and dry them after each distillation, as it is extremely difficult to remove any odor or taint that adheres to the still, still-head, and worm. Even blowing steam through them for some hours will not always sufficiently purify them for this species of distillation. In the preparation of distilled waters for medicinal purposes, a clean, sweet still, still-head, and worm, must also be employed. The two last should be of tin or glazed stoneware; and the receivers should be of glass or stoneware. The utmost care should be taken to prevent contamination of distilled waters by contact with copper, lead or zinc, since they slowly oxidize and dissolve these metals. In almost all cases, salted or pickled flowers, herbs, &c., are greatly superior to the fresh vegetables for the preparation of fragrant distilled waters. When the former are employed the product has little or none of the herbaceous and raw odor which is always present when the latter are used, besides which they keep better, and reach maturity, or the full development of their odor, in a much shorter time. (*See No.* 1349.) Carefully prepared distilled waters keep well, and are not liable to any change, but when the reverse is the case, particularly when the liquor in the still has spirted over the neck of the still-head into the condensing worm, they are apt to acetify, and even to become ropy and viscid. A common, but very objectionable plan, in such cases, is to agitate them with a little carbonate of magnesia, and to filter them through paper. The only safe remedy is to re-distill them on the first indication of such change, for magnesia weakens them. Indeed, all their essential oil and fragrance may be removed by increasing the quantity of it. If magnesia, in any form, be used for filtering distilled waters, it should be the carbonate; but a little of even that will be dissolved if the water be ever so slightly acidulous.

1074. To Remove the Burnt Smell of Freshly Distilled Waters. The burnt smell of waters, frequently arising from careless stilling, is usually lost, or greatly lessened, by freezing, or by exposure to a temperature approaching the freezing point; but if the water be highly charged with essential oil, part of the latter will separate, and thus the water will lose some of its fragrance. (*See No.* 1076.)

1075. To Prevent Distilled Waters from Souring. To prevent carelessly prepared distilled waters acetifying or turning sour, and to recover those which have begun to spoil, a common plan is to shake them up with a little calcined magnesia, or to dissolve in each pint of them 1 grain each of powdered borax and alum. This, however, is not to be recommended, as it unfits the waters for use as vehicles. Whenever it is unavoidably had recourse to, the best plan is to re-distill the water a few days afterwards.

1076. Practical Suggestions for Making Distilled Waters. There are certain general rules or points to be adhered to in distilling perfumed waters: Dry, hard, or fibrous substances should be mechanically divided, and macerated in water before undergoing distillation. Too great a quantity of materials should not be introduced at one time into the body of the still; if this precaution be neglected, there is a risk of the liquid boiling over or spirting into the receiver. Ebullition should be attained as quickly as possible, and be continuous. Sufficient water should be left undistilled to cover the matter in the still, to guard against its coming in contact with the sides of the vessel. In this case the matter would be decomposed by the heat, and yield empyreumatic products; besides, if the distillation is carried too far, a slimy formation is apt to adhere to the sides of the still, which would also be decomposed by the heat, and have a similar effect on the product. These risks may be greatly lessened, if not entirely avoided, by applying heat by means of an oil-bath, regulated by a thermometer; and still better by a bath containing a solution of chloride of calcium (muriate of lime). Any degree of heat between 212° and 285° Fahr. may be obtained and sustained by regulating the strength of the solution. (*See No.* 7.) Another convenient method is by steam. (*See No.* 1077.) Waters distilled from plants are apt to have a smoky odor at first, even when the greatest care and precaution have been observed in their distillation; exposure for a short time to the air will remove this, after which they should be kept in closely-stoppered bottles, and preferably in bottles containing only sufficient for probable use at one time; they should be entirely filled and closed air-tight.

1077. Soubeiran's Steam Apparatus for Distilled Waters. The illustration given is a vertical section of Soubeiran's apparatus used in France for obtaining distilled waters. A cylindrical tinned-copper or iron boiler, *A*, of convenient size, say 3½ feet high and 2 feet in diameter, is surmounted by an expanded head or capital, *B*, which is furnished with an inner ledge, forming a kind of gutter, to receive the liquid condensed on the inner surface



of the capital, and opening into the exit tube, *e*. About 6 inches from the bottom of the cylinder is placed a false bottom or diaphragm, *c*, pierced with small holes. A steam pipe, *d*, having a stop-cock, *a*, is introduced in the cylinder in the manner shown, terminating in an expansion, *b*, perforated like the rose of a watering-pot, and located a little below the diaphragm.

The material to be distilled, after proper preparation, is placed upon the diaphragm, the capital, *B*, is applied and luted with dextrine paste; steam is passed through the tube, and issuing from *b*, passes through the material, becomes loaded with the volatile matter, rises into the capital, condenses, and passes through *f*, into a worm or other suitable condenser.

1078. Vanilla Water. Macerate 1 pound vanilla in coarse powder, and 5 pounds salt in 2¼ gallons water for 24 hours. Then distill over rapidly 1 gallon.

1079. Rose Water. Take 48 Troy ounces pale rose, and 16 pints water. Mix them and distill 8 pints. When it is desirable to keep the rose for some time before distilling, it may be preserved by being well mixed with ⅓ its weight of chloride of sodium (table salt). U. S. Ph. (*See No.* 1008.)

1080. To Prepare Aromatic Waters from Essential Oils. The United States Pharmacopœia, although not discarding altogether the process of distillation in the preparation of aromatic water, directs, in preference, that water should be impregnated with the volatile oil by trituration with carbonate of magnesia, and subsequently filtered. This is the most simple and easy process. The water is obtained pure and transparent, the magnesia being separated by the filtration. The object of the magnesia is simply to enable the oil to be brought to a minute state of subdivision, and thus present the largest possible surface to the water; but its use is open to the objection that it is slightly soluble in water, and is apt to produce, under certain circumstances, a slightly flocculent precipitate. It has been recommended to use porcelain clay, finely powdered glass, or pumice stone, instead of magnesia, as these substances are wholly insoluble. (*See No.* 1073 *and* 1081.)

1081. Aromatic or Perfumed Waters. Take 2 fluid drachms of the essential oil of the plant, triturate with 2 drachms levigated powdered silex; then add very gradually, with constant trituration, 8 pints distilled water. After brisk agitation for some time, filter the solution through filtering paper wetted with pure water. This is a convenient method for the extemporaneous preparation of perfumed waters, but, without great care in manipulating, the products are inferior in strength to those obtained by distillation. Finely powdered or levigated glass may be used when silex (quartz) is unobtainable. Magnesia and sugar were each formerly used for the purpose, but are objectionable. (*See No.* 1080.

1082. Aromatic or Perfumed Waters. Instead of preparing the waters directly from the essential oils, an essence may be made by dissolving 1 Imperial fluid ounce of the essential oil in 9 fluid ounces rectified spirit; 2 Imperial fluid drachms of the essence agitated briskly for some time with 1 Imperial pint distilled water, and filtered through wet filtering paper, will make a good perfumed water. Cooley says this is an excellent formula for extemporaneous waters; but the U. S. Dis. pronounces them feeble for medicated purposes, in the properties of their respective essential oils. (*See No.* 1008.)

Perfumed Powders and Rouges.

Powders for the hair and skin have almost gone out of use. The basis of perfumed powders is either orris, or fine pearl starch. The perfume of the finest kinds is imparted by alternating layers of starch and fresh flowers, the latter being afterwards separated by sifting. The simple perfumed powders thus obtained, by judicious admixture, form compound or bouquet powders. The tediousness and expense of this process prevent its general employment. The common mode is to scent by the direct addition of extracts or essential oils, or else to mix in powdered fragrant material with the orris or starch.

1100. Violet Powder. Wheat starch, 12 pounds; powdered orris, 2 pounds. Mix together, and add attar of lemon, ½ ounce; attars of bergamot and cloves, each 2 drachms.

1101. Poudre d'Iris. Powdered orris root, 12 pounds; powdered bergamot peel, and acacia flowers, each 8 ounces; powdered cloves, ½ ounce. Mix and sift.

1102. Prepared Bran for the Hair. Powdered wheat bran, 1 pound; powdered orris, 2 ounces. Mix and sift.

1103. Poudre Noir for the Hair. Starch and orris in fine powder, each 8 ounces; charcoal and ivory black, in fine powder, each 1 ounce. Mix and sift.

1104. Poudre Blonde for the Hair. Finely powdered starch and orris, 8 ounces each; as in the preceding, but with yellow ochre for the coloring matter.

1105. Poudre à la Vanille Brune for the Skin or for Sachets. Powdered vanilla, rose leaves, lamp storax, benzoin, rhodium, palissandre and ebony woods, each 1 pound; powdered cloves, 2 ounces; powdered musk, 2 drachms. Mix together with 3 pounds of starch; sift, and add a few drops of extracts of tuberose and jasmin.

1106. Poudre à l'Œillet Composée—for the Skin or Sachets. Powdered rose leaves and orris root, each 3 pounds; powdered bergamot peel, 1 pound; powdered cloves and cinnamon, each 6 ounces; powdered acacia and orange flowers, each 8 ounces; starch, 3 pounds.

1107. Paints or Rouges for the Skin. Paints or rouges are the means by which the natural color of the skin may be heightened or changed. They are, however, objectionable preparations, and the use of them extends very little beyond the theatres, where they are employed to produce stage effect.

1108. French White. This is the mineral talc, or French chalk, finely powdered and bolted. It forms the basis of the most harmless rouges. Perfume is added as may be desired.

1109. Pearl White. Pure oxide or subnitrate of bismuth in powder. This pigment darkens in atmospheres containing sulphide of hydrogen. 1 ounce triturated with 4 ounces of orange-flower water makes liquid white for theatrical use.

1110. Pearl Powder. Precipitated chalk finely bolted and perfumed. The French add oxides of zinc and bismuth, each 1 ounce to the pound of chalk.

1111. Caution against Bismuth as a Cosmetic. The continued use of bismuth-white injures the skin, and ultimately produces paralysis of its minute vessels, rendering it yellow and leather-like—an effect which, unfortunately, those who employ it generally attempt to conceal by its freer and more frequent application.

1112. Carmine Rouge. Finely bolted talc, 4 ounces; carmine, 2 drachms. Mix together with a little warm and dilute solution of gum tragacanth. For lighter shades, the proportion of carmine must be diminished. For commoner pastes, rose-pink replaces the carmine as coloring matter. It may be made into a pomade.

1113. Bloom of Roses. Powdered carmine of the best quality, 2 drachms, digested with strong ammonia, 4 ounces, in a tightly stoppered bottle for 2 days, at the ordinary temperature of the atmosphere. Then add rose water, 1 pint; and essence of rose, 4 ounces. After standing for a week to settle, the clear liquid may be poured off from the sediment, and bottled.

1114. Azure Paste. Talc and ultramarine, finely bolted, equal parts, triturated with a solution of gum tragacanth into a stiff paste.

1115. Enamel Powder. Take equal parts finely scraped talc or French chalk, and pearl-white; sufficient rouge or carmine to slightly tinge it; mix. Used to conceal discolorations; and, without the coloring, to whiten the skin.

Cosmetics for the Skin and Complexion.

The preparations under this head are designed to soften the skin and beautify the complexion. We annex receipts for the more important. The heating medium in the manufacture of them must be either a water or steam bath.

1117. To Make Amandine. Put into a large marble mortar 2 ounces gum arabic, and 6 ounces white honey; triturate, and when the mixture has been rubbed into a thick paste, add 3 ounces perfectly neutral almond shaving cream. (*See No.* 602.) Then continue the trituration until the mixture has become homogeneous. 2 pounds of fresh cold-pressed sweet almond oil are next allowed to flow from a can above into the mortar, but only as rapidly as it can be incorporated with the mass; otherwise, if it enters in too large quantities, the blending is imperfect, and the amandine becomes *oily* instead of jelly-like and transparent, as it should be when the manipulation has been skillful. In summer temperatures it will be difficult to effect a combination of all the oil; and, therefore, the flow should be stopped as soon as the mixture becomes bright and assumes a crystalline lustre. The perfume should be mixed with the almond oil, and consists of ½ drachm attar of bitter almonds to every pound of paste. A little attar of rose and bergamot may also be added—about 1 drachm of each. As soon as finished it must be put in close pots.

1118. To Use Amandine. To produce amandine of fine quality is a matter of some difficulty and labor, and requires experience and considerable manipular skill. The details essential to success are noticed under "Emulsions." (*See No.* 43.) A small quantity, say a lump of filbert size, gives with warm water a rich lather, which, when rubbed over the face and hands, imparts softness, and prevents chapping. It should be wiped off while still in lather, with a dry towel.

1119. Glycerine Amandine. As the preceding, but adding, with the shaving cream, ½ to 1 ounce of Price's glycerine for every pound of oil intended to be subsequently added.

1120. Colored Amandine. Amandine may be colored green with spinach-leaves, and yellow and orange with palm oil or annotto, by digesting or dissolving the substances in the oil before adding the scents. A beautiful scarlet or crimson may be given to it by adding a little liquid rouge or carmine (ammoniacal), just before removing it from the mortar. *Olivine* is a similar preparation to amandine, but made with olive-oil. It is often colored green.

1121. Cosmetic Balsam of Honey. Take finest pale honey, 4 ounces (avoirdupois); glycerine (Price's), 1 ounce; unite by a gentle heat; when cold, add rectified spirit, 1 fluid ounce (Imperial); essence of ambergris, 6 drops; and at once bottle it. Used to soften and whiten the skin, prevent chaps, &c.

1122. Freckle Balsam. To the balsam of honey prepared as directed in the last receipt, add pure citric acid, 3 drachms. Used to prevent and remove freckles and discolorations.

1123. Almond Paste. Reduce blanched almonds to a very smooth paste by patiently pounding them in a marble mortar, adding gradually, toward the end, a little rose-water, or orange-flower water, with a few drops of attar of roses or neroli, or a little eau de Cologne, or other perfume, at will. Lastly, put the paste into covered porcelain pots or jars.

1124. Bitter Almond Paste. Take equal parts bitter almonds and sweet almonds; and rose-water, a sufficient quantity; and proceed as before. No scent need be added. Both the preceding are occasionally diversified by the addition of either powdered spermaceti in weight equal to about ⅛ part of that of the almonds, or of ⅙ this weight of white soap. Sometimes the white of an egg is added.

1125. Cold Cream. Take 1 ounce avoirdupois each pure white wax and spermaceti, and ½ Imperial pint oil of almonds; melt, pour the mixture into a marble or wedgwood-ware mortar (or a porcelain basin), which has been heated by being immersed for some time in boiling water; add, very gradually, of rose-water, 4 fluid ounces; and assiduously stir the mixture until an emulsion is formed, and afterwards until the whole is very nearly cold. Lastly, put it into porcelain or earthenware pots for use or sale.

1126. Hudson's Cold Cream. This is prepared in the same way as the above, with the addition of 1 fluid ounce orange-flower water.

1127. Sultana Cold Cream. Take ½ ounce avoirdupois each, pure spermaceti and white wax; almond-oil, and butter of cacao, each ½ pound; melt, and stir in of balsam of Peru, 2 drachms. After repose, pour off the clear portion, add orange-flower water, 2 Imperial fluid drachms, and stir it briskly until it concretes. Used like cold cream, lip-salve, &c.

1128. Crême de Cathay. Melt together over a water bath, white wax and spermaceti, each 2 drachms; then add oil of sweet almonds, 4 ounces, and Mecca balsam, 3 drachms; next perfume with rose-water, 6 drachms; stir until cold.

1129. Glycerine Cream. This superior cosmetic is the well-known *cold-cream*, (*see No.* 1125), with glycerine substituted for rose-water. Melt together spermaceti, 6 ounces; and white wax, 1 ounce, in 1 pound of sweet almond oil. Then remove from the fire, and stir in Price's glycerine, 4 ounces; and when congealing, perfume with attar of rose, 20 drops. Other attars may be used as desired, in place of rose.

1130. Rose Glycerine Cream. Spermaceti, ½ ounce; oil of sweet almonds, 2 ounces; white wax, 1 ounce; glycerine, 4 ounces: mix the spermaceti, white wax and oil of almonds together first; then add the glycerine and stir the mixture until cool. Perfume with attar of rose.

1131. Snow Cream. Melt 3 ounces spermaceti, 2 ounces white wax, and 12 ounces fresh oil of almonds, in a water-bath; pour it into a marble mortar, and stir briskly to prevent granulation; when of the consistence of butter, triturate until the mixture has a white, creamy appearance; then, during continued trituration, add by degrees a mixture of 1 ounce double water of roses and 1 ounce odorless glycerine; incorporate for 20 minutes, and add 10 drops essence of roses; beat for about half an hour, put into pots or jars, and close air-tight.

1132. Fine Camphor Ice. Melt together over a water-bath, white wax and spermaceti, each 1 ounce; camphor, 2 ounces; in sweet almond oil, 1 pound. Next, triturate in the manner directed for amandine, and allow 1 pound of rose-water to flow in slowly during the operation. Then perfume with attar of rosemary, 1 drachm. An inferior and cheaper quantity may be made as follows:—

1133. Camphor Ice. Oil of sweet almonds, 2 ounces; spermaceti, 4 ounces; white wax, 2 ounces; camphor, ½ ounce; melt them over a water-bath, run in moulds of proper size and form.

1134. Pate d'Amande au Miel. Rub together 1 pound honey and the yolks of 8 eggs; then gradually add sweet almond oil, 1 pound, during constant trituration, and work in bitter almonds—blanched and ground to meal, 8 ounces; finally perfume with attars of bergamot and cloves, each 2 drachms.

1135. Pomade Rosat. Melt together white wax, 2 ounces; oil of sweet almonds, 4 ounces; alkanet, 3 drachms. Digest for several hours, strain, and add 12 drops attar of rose; used for the lips.

1136. Cacao Pomade. Take of cacao butter, oil of almonds, white wax (pure), equal parts; melt them together, and stir until nearly cold. Used as an emollient skin-cosmetic, particularly for chapped lips, hands, &c. It is sometimes colored with a little palm-oil. Scent may be added at will. It is highly esteemed by some persons as a hair pomade.

1137. Crême de Psyché—for the Lips. White wax and spermaceti, each 1 ounce; oil of sweet almonds, 5 ounces. Melt together, and pour in Mecca balsam, 1 drachm; and stir until the mass congeals, then add 10 grains powdered acetate of lead.

1138. Lait Virginal. Orange-flower water, 8 ounces; and tincture of benzoin, 2 drachms. The former is added very slowly to the latter during constant trituration, so as to produce an opalescent milky fluid.

1139. Crême de Pistache. Pistachio nuts, 3 ounces; green oil, palm soap, wax, and spermaceti, each 1 ounce; orange-flower water, 3½ pints; essence of neroli, 12 ounces; make as directed for the preceding milks.

1140. Milk of Roses. Place over a water-bath, oil soap, 1 ounce; and melt it in 5 or 6 ounces rose-water; then add white wax and spermaceti, 1 ounce, and continue the heat until they have melted. Next take 1 pound blanched almonds, beat them to a meal in a clean marble mortar, with 3½ pints rose-water, admitted portionwise, during the trituration. (*See No.* 43.) The emulsion of almonds, thus made, is to be strained without pressure through washed white muslin, and run very slowly into the previously formed soap-mixture; the whole being blended at the same time by energetic trituration. Towards the end of this operation, 2 drachms attar of rose, dissolved in 8 ounces inodorous alcohol, are to be let into the mixture very gradually, and in a thin stream, during constant rubbing of the mass. This cautious manipulation is indispensable to the smoothness and perfection of the milk. (*See No.* 43.) The last operation is to strain; and, after the liquid has had a day's repose, to bottle it. This is a highly esteemed cosmetic for the skin and complexion. Milk of cucumbers may be made in the same manner as milk of roses, by substituting juice of cucumbers for rose-water.

1141. Lotion for Freckles. Take bichloride of mercury, 6 grains avoirdupois; pure hydrochloric acid, specific gravity 1.15, 1 Imperial fluid drachm; distilled water, ½ pint; mix, and add rectified spirit and eau de rose, each 2 fluid ounces; Price's glycerine, 1 ounce.

1142. Lotion to Remove Freckles. Dissolve 3 grains borax in 5 drachms each rose-water, and orange-flower water; a very simple and harmless remedy is equal parts of pure glycerine and rose-water, applied every night, and allowed to dry.

1143. Iodine Lotion for Eruptions of the Skin. Take iodide of potassium, 30 grains avoirdupois; iodine, 15 grains; distilled or soft water, 1 Imperial pint; add only a couple of table-spoonfuls of the water at first, and when by agitation the solids are dissolved, add the remainder. This is the common and best form of ioduretted lotion or wash for ordinary purposes. It is often serviceable in enlarged and indurated glands, itch, &c. Or: take iodide of potassium, 1 to 2 drachms, and distilled water, 1 pint; dissolve.

1144. Glycerinated Lotion of Iodide of Potassium. To the last add 1 ounce Price's glycerine. Both are excellent skin-cosmetics, employed like Gowland's lotion particularly for persons with a scrofulous or scorbutic taint, or who are troubled with eruptions, swellings, or indurations arising from it. It is also excellent as a hair-wash. The product of the last formula may be advantageously used instead of hair-oil.

1145. Lotion of Bichloride of Mercury. Take corrosive sublimate (in coarse powder), 10 grains avoirdupois; distilled water 1 Imperial pint; agitate them together until solution be complete. The addition of 5 or 6 grains hydrochlorate of ammonia (pure sal-ammoniac) or 5 or 6 drops (not more) hydrochloric acid, increases the solvent action of the water, and renders the preparation less liable to suffer change, but is not otherwise advantageous. When absolutely pure distilled water is not used, this addition of acid should be made to prevent decomposition. Some persons dissolve the sublimate in 2 or 3 fluid drachms rectified spirit before adding the water, to facilitate the process; but this also, though convenient, is unnecessary. Apart from its value as a cosmetic, the above lotion is an excellent application in a variety of obstinate eruptions, and in obstinate sores and glandular swellings and indurations of a milder character; the first of which it seldom fails to relieve, provided the bowels and diet be carefully attended to, and sufficient exercise be taken daily. Ordinary mild cases of itch rapidly disappear under its use. The addition of about 1 ounce pure glycerine converts it into a lotion admirably adapted to allay itching and irritation generally, as well as into one of the best cosmetic washes known. For the latter purpose, a little pure rose water or orange-flower water may be added, at will, to give it fragrance; a like quantity of distilled water, in the case of any of the above additions, being omitted.

1146. Eau de Beauté. Bichloride of mercury (corrosive sublimate), 8 grains; camphor, 10 grains; sulphate of zinc, and solution of lead (liquor of acetate of lead), each 2 scruples; rose water 5½ ounces; and the yolk of a small egg. This mixture is regularly in use by Creole ladies for beautifying their skin.

1147. Glycerine Lotion. Take Price's glycerine, 1 ounce, and distilled or pure soft water, 19 ounces; mix. A good strength for daily use as a cosmetic wash, or as a vehicle for other ingredients, for which purpose it is greatly preferable to milk of almonds; also as a lotion to allay itching and irritation of the skin, prevent chaps, excoriations, the effects of weather, climate, &c. It is likewise applied to the hair instead of oil.

1148. Glycerine Lotion No. 2. Take of Price's glycerine, 1 ounce, and distilled water, 17 ounces; mix. A proper strength when more marked effects are desired; as in chapped hands, lips, and nipples, obstinate excoriations, abrasions, chafings, sunburns, persistent roughness or hardness of the skin, &c.

1149. Glycerine Lotion No. 3. Take of Price's glycerine, 3 ounces; water, 17 ounces; mix. This is adapted for use in obstinate cases, or when still more rapid effects are desired; also as an application to burns and scalds.

1150. Fragrant Glycerine Lotions. Any of the foregoing glycerine lotions may be rendered fragrant and more agreeable by employing rose water or elder-flower water, instead of water, or by the addition of a little eau de Cologne, lavender water, or other scent, at will. The addition of a few drops of essence of musk or of ambergris, per pint, or of a couple of ounces of eau de rose or eau de fleurs d'oranges, in lieu of an equal bulk of water, imparts a delicate odor which is always highly esteemed. In like manner they may be medicated or increased in efficacy, in various ways, for toilet and personal use. Thus, the addition of a little borax (2 or 3 drachms per pint), renders them more effective in chaps, excoriations, &c.; a little salt of tartar, or of lemon juice, vinegar, or rectified spirit, increases their power of allaying itching and morbid irritability in skin-diseases, as well as converts No. 1 (more particularly) into an excellent wash for freckles and like discolorations. 8 or 10 grains of bichloride of mercury, per pint, converts it into the admirable lotion of that substance. (*See No.* 1145.) In like manner, by the addition of a drachm or so of iodide of potassium, or of compound tincture of iodine, we have a healthful cosmetic wash particularly serviceable to persons with a scrofulous taint. Strongly scent it with the oils of origanum and rosemary, or impregnate it with a certain proportion of cantharides, or some other appropriate stimulant and rubefacient, and we have respectively the most cleanly, convenient, and useful hair cosmetics. Indeed, merely to enumerate all the uses it may be placed to in the cosmetic and allied treatment of the person, would alone fill many pages.

1151. To Test the Purity of Glycerine. Glycerine weighed at the temperature of 60° Fahrenheit should have no less than 29° B.; if it contains lime or alkalies, one degree should be deducted, as these substances make it heavier.

Rubbed on the hand, it should be perfectly inodorous. Impure glycerine, under this test, has a disagreeable smell. The impurity causing this odor is mostly butyric acid, as by contact with the glycerine it forms a very volatile glycerole. Such an article will always grow worse by age.

The presence of *chlorine*, sometimes used for bleaching glycerine, is detected by tinging the sample blue with sulphate of indigo, and then adding a little sulphuric acid; if free chlorine, or chloride of calcium, be present, the blue color will disappear.

If a few drops of a solution of nitrate of silver be added to glycerine, the presence of *chlorine* is marked by the formation of a white precipitate.

Oxalate of ammonia will precipitate *lime*, if present. *Lead* will be detected in the same way by hydrosulphate of ammonia; and *sulphuric acid* by a soluble salt of baryta.

Cane sugar may be traced by increased sweetness of taste; also by dissolving the glycerine in chloroform, in which it is completely soluble if pure, sugar being insoluble in it.

1152. Caution About Glycerine. The property which has caused most annoyance in the use of glycerine is its strong affinity for water. Although glycerine has a pleasant, sweetish taste, yet the first sensation that is felt when it is applied to the tongue is one of pain and burning. This is caused by the fact that the glycerine absorbs all the moisture from the surface that it touches, and thus dries it up and parches the nerves. Ignorant of this fact, nurses and mothers have applied pure glycerine to the chafed skin of infants, and produced great pain. The glycerine ought to have been first mixed with an equal bulk of water, or at least with so much as would remove its burning action on the sense of taste. This being done, it may be applied to the most tender surfaces without producing injury, and as it does not dry up, virtually maintains the parts in a constantly moist condition, excluding the air and promoting the healing process.

1153. Fine Glycerine Lotion. Glycerine, 3 fluid ounces; quince-seed mucilage, (*see next receipt*), 10 fluid drachms; pulverized cochineal, 5 grains; hot water, 1½ fluid ounces; inodorous alcohol, 2½ fluid ounces; oil of rose, 8 drops; pulverized gum-arabic; ½ drachm; water, 8 fluid ounces. Rub the powdered cochineal first with the hot water gradually added, and then add the alcohol. Then triturate the oil of rose well with the powdered gum-arabic, and gradually add the water as in making emulsion. (*See No.* 43.) With this mix well the solution first formed, and filter, and to the filtered liquid add the glycerine and mucilage of quince seeds, and shake well. The mucilage of quince seeds should always be freshly made. If the alcohol is sweet and free from foreign odor, and the glycerine perfectly inodorous, a less quantity of oil of rose may suffice. If care is taken in its manufacture, this will form a beautiful and elegant preparation, with a rich rosy fragrance. When applied to the skin it imparts an agreeably soft, smooth, and velvety feel. It is an excellent application for the face after shaving, or for allaying the irritation caused by exposure to the wind.

1154. Quince Mucilage. The mucilage of quince seeds may be made by boiling for 10 minutes 1 drachm quince seeds in ¼ pint water, and straining. This is sometimes used as a bandoline, but it soon decomposes, and, therefore for that purpose, only very small quantities should be prepared.

1155. Gowland's Lotion. The formula sanctioned by the medical profession is to take of Jordan almonds (blanched), 1 ounce; bitter almonds, 2 to 3 drachms; distilled water, ½ pint; form them into an emulsion. To the strained emulsion, with agitation, gradually add of bichloride of mercury (in coarse powder), 15 grains previously dissolved in distilled water, ½ pint. After which further add enough water to make the whole measure exactly 1 pint. Then put it in bottles. This is used as a cosmetic by wetting the skin with it, and gently wiping off with a dry cloth. It is also employed as a wash for obstinate eruptions and minor glandular swellings and indurations.

1156. Lotion of Borax, for Sore Gums and Nipples. Take 5 drachms powdered borax; distilled water, ½ pint; mix. An effective wash for sore gums, sore nipples, excoriations, &c., applied twice or thrice daily, or oftener.

1157. Glycerinated Lotion of Borax for Chaps and Sunburns. Take 6 drachms avoirdupois powdered borax; Price's glycerine, ¾ ounce; rose-water or elder-flower water, 12 ounces; mix. Resembles the last, but is fragrant and much more agreeable and effective. Its daily use as a cosmetic wash renders the skin beautifully soft and white, and prevents and removes chaps, sunburns, &c.

1158. Cazenave's Lotion of Cyanide of Potassium. Take cyanide of potassium, 5 grains avoirdupois; emulsion of bitter-almonds, 3 Imperial fluid ounces; dissolve. Used like the last, to allay itching and irritation, particularly after shaving; also for freckles and pustules. (*See No.* 43.) The above is Cazenave's formula. The next receipt is, however, preferable.

1159. Glycerinated Lotion of Cyanide of Potassium. Take cyanide of potassium, 6 grains avoirdupois; glycerine, ½ ounce; strongest camphor-water, 2½ ounces; mix. (*See No.* 1160.)

1160. Caution Against Cyanide of Potassium. Cyanide of potassium is highly poisonous when swallowed, and as the above lotions are pleasant-tasted, they should not be left out of the dressing-case; nor should a larger quantity than that above given be kept in use at once; nor, under ordinary circumstances, should they be applied to a large surface at a time. If not kept under lock and key, it is safest to label them *Poison.* Kept with care, and properly employed, they are safe and useful lotions.

1161. Cherry-Laurel Lotion, or Shaving Wash. Take genuine distilled cherry-laurel, 2 Imperial fluid ounces; rectified spirit, 1 fluid ounce; glycerine, ⅛ ounce; distilled water, 7½ fluid ounces; mix. Used to allay irritation of the skin, particularly after shaving, the part being moistened with it by means of the tips of the fingers; also used as a wash for freckles and pustules, and to remove excessive moistness or greasiness of the hair. Milk of bitter-almonds is often substituted for the glycerine and spirit, but not for the hair.

1162. Glycerine and Borax Lotion for the Complexion. Mix ½ ounce powdered borax, and 1 ounce pure glycerine, with 1 quart camphor-water. Wet the face morning and evening with this lotion, allowing it to dry partially, and then rinse off with soft water.

1163. Pomade de Ninon de l'Enclos. Take of oil of almonds, 4 ounces avoirdupois; hog's lard, 3 ounces; spermaceti, 1 ounce; melt, add of expressed juice of house-leek, 3 Imperial fluid ounces, and stir until the mixture solidifies by cooling. A few drops of esprit de rose, or of eau de Cologne, or lavande, may be added to scent it at will. Used as a general skin-cosmetic; also for wrinkles and freckles. It is said to be very softening, cooling, and refreshing.

1164. Pomade de Beauté; Pomade de Vénus. Take of oil of almonds, 1 pound; spermaceti (pure), 2 ounces; white wax (pure), 1½ ounces; glycerine (Price's), 1 ounce; balsam of Peru, ½ ounce; mix by a gentle heat, and stir the mass until it begins to solidify. It is sold either white, or tinted of a delicate rose or green color. Used both as a hair and skin cosmetic. It forms an elegant substitute for ordinary cold-cream, lip-salve, &c., and is much recommended by the makers for improving the quality and promoting the growth of the hair.

1165. Shaving Paste; Pate pour Faire la Barbe. Take of Naples-soap (genuine), 4 ounces; curd-soap (air-dried and powdered), 2 ounces; honey (finest), 1 ounce; essence of ambergris (or essence royale), oil of cassia, oil of nutmeg, of each 10 drops; beat them to a smooth paste with water or eau de rose; and put it into covered pots. (*See Nos.* 602, *&c., and* 607.)

1166. Shaving Paste. Take of white soft-soap (*see No.* 600), 4 ounces; honey-soap (finest, sliced), 2 ounces; olive-oil, 1 ounce; water, 1 or 2 table-spoonfuls; carbonate of soda, 2 drachms; melt them together, and form a paste, as before, adding a little proof spirit and scent, at will. Some persons melt with the soap about 1 drachm of spermaceti.

1167. Colored Collodion for the Skin. 1 ounce collodion, 3 grains each pure annotto and dragon's blood; digest, with agitation, in a stoppered phial, for 24 hours; and, if necessary, decant the clear portion.

1168. Flesh Colored Collodion. 2 ounces collodion; 1 drachm palm oil; alkanet, 15 grains; digest, &c., as in the last receipt. This dries of a good skin color; but it is not so strong as the product of the preceding formula.

1169. Glycerinized Collodion may be obtained by substituting 2 drachms of glycerine for the palm oil in the preceding receipt. This is exceedingly supple, does not crack or scale off from the skin, and accommodates itself to the motions of the part.

1170. Peruvian, or Red Lip Salve. Take of spermaceti ointment, $\frac{1}{2}$ pound; alkanet root, 3 or 4 drachms; digest, at a gentle heat, until the first has acquired a rich deep red color, then pass it through a coarse strainer. When the liquid fat has cooled a little, stir in thoroughly 3 drachms balsam of Peru. In a few minutes pour off the clear portion from the dregs (if any), and add 20 to 30 drops oil of cloves. Lastly, before it cools, pour it into the pots or boxes. The product forms the finest and most esteemed *lip salve.* 2 or 3 drops of essence of ambergris, or of essence royale, improve and vary it.

1171. Rose Lip Salve. As the above, but using only $1\frac{1}{2}$ drachms balsam of Peru, and replacing the oil of cloves with a few drops of attar of roses, or sufficient to give the mixture a marked odor of roses. Some makers omit the balsam altogether. If uncolored, it forms white rose lip salve. (*See No.* 1135.

1172. White Lip Salve. Take $\frac{1}{2}$ pound spermaceti ointment, liquify it by the heat of warm water, and stir in $\frac{1}{2}$ drachm neroli or essence de petit-grain as before.

1173. Glycerine Lip Salve. This is prepared by adding $\frac{1}{6}$ to $\frac{1}{5}$ part of glycerine to any one of the above whilst in the melted state, and stirring the mixture assiduously until it begins to cool.

1174. French Lip Salve. Mix together 16 ounces lard, 2 ounces white wax, nitre and alum in fine powder, of each, $\frac{1}{2}$ ounce; alkanet to color.

1175. German Lip Salve. Butter of cacao, $\frac{1}{2}$ ounce; oil of almonds, $\frac{1}{2}$ ounce; melt together with a gentle heat, and add 6 drops essence of lemon.

1176. Gants Cosmétiques. These are white kid gloves, which have been turned inside out, and brushed over with a melted compound of wax, oil, lard, balsam, &c. The Peruvian lip salve (*see No.* 1170) without the alkanet, may answer the purpose. An excellent method for softening the hands.

Washes for Failing Hair or Baldness.

Liniments or washes to make the hair grow, can always be employed, with greater or less success, so long as there is any vitality left in the hair follicles or roots. If, however, these are entirely dead or destroyed, there is no possibility of inducing a fresh growth of hair. This will be evident from the shining or glistening appearance the scalp assumes when the hair roots are destroyed. The loosening of the hair, which frequently occurs to young persons, or those of the middle period of life, will generally, if neglected, become real baldness. Such a state is common in women, and generally terminates, in its mildest form, in excessive loosening of the hair. The case, however, is not the hopeless one which is generally imagined; and if proper treatment be pursued, the hair will grow afresh, and assume its pristine strength. A useful practice in men, and those of the opposite sex whose hair is short, is to immerse the head in cold water morning and night, dry the hair thoroughly, and then brush the scalp, until a warm glow is produced. For women with long hair, this plan is objectionable; and a better one is to brush the scalp until redness and a warm glow are produced, then dab among the roots of the hair one or other of the hair lotions. If the lotion produce smarting or tenderness, the brush may be laid aside, but if no sensation is occasioned, the brushing should be resumed, and a second application of the lotion made. This treatment should be practiced once or twice a day, or at intervals of a few days, according to the state of the scalp: namely, if tender, less; if insensible, more frequently. When the baldness happens in patches, the skin should be well brushed with a soft tooth brush, dipped in distilled vinegar morning and evening, or dipped in one of the washes given below. If either of these lotions should be found too irritating to the skin, use them in smaller quantity, or diluted, and less frequently. If they have the effect of making the hair harsh and dry, this inconvenience may be removed by the use of oil or pomatum after each application of the lotion. Pomatums for the growth of the hair are very inferior to the lotions in efficacy. The basis of most hair invigorators and restorers is either the tincture or the vinegar of cantharides; the method of preparing the latter ingredient is given in the next receipt.

1178. To Prepare Vinegar of Cantharides. This preparation is not always obtainable in the drug stores, and is made by macerating, with agitation for 8 days, 2 ounces powdered cantharides in 1 pint acetic acid; then press and strain.

1179. Wash for Restoring Hair. Mix $\frac{1}{2}$ ounce vinegar of cantharides with 1 ounce eau de Cologne and 1 ounce rose water. Or, $\frac{1}{2}$ ounce tincture of cantharides, 2 ounces eau de Cologne, $\frac{1}{2}$ drachm oil of nutmeg, and 10 drops oil of lavender.

1180. Morfit's Hair Tonic. Scald black tea, 2 ounces, with 1 gallon boiling water; strain, and add 3 ounces glycerine; tincture cantharides, $\frac{1}{2}$ ounce; and bay rum 1 quart. Mix well by shaking and then perfume.

1181. Regenerative Glycerine Hair Wash. Take 1 ounce, avoirdupois, glycerine (Price's); strongest eau de Cologne, $\frac{1}{2}$ Imperial pint; liquor of ammonia (specific gravity 880-882), 1 fluid drachm; oil of origanum and oil of rosemary, each, $\frac{1}{2}$ fluid drachm; tincture of cantharides, 1 fluid ounce; briskly agitate them together for 8 or 10 minutes, then add $\frac{1}{2}$ pint strongest camphor water, and again well agitate. A few drops of essence of musk are often added. An excellent hair lotion, and one that supersedes the necessity of using oil or pomade.

1182. Erasmus Wilson's Hair Wash. Take 8 Imperial fluid ounces strongest eau de Cologne; tincture of cantharides, 1 fluid ounce; English oil of lavender, and oil of rosemary, each, $\frac{1}{2}$ fluid drachm; mix. It is improved by the addition of $\frac{1}{2}$ fluid drachm oil of origanum, or by its substitution for the oil of lavender; but the omission of the latter renders it less odorous.

1183. Parisian Wash to Gradually Darken the Hair. Take of green sulphate of iron, 15 to 20 grains; distilled verdigris, 5 or 6 grains; good white wine, $\frac{1}{2}$ Imperial pint; perfume with eau de Cologne to suit; mix. A favorite among the fashionable Parisians. The above will iron-mould linen if permitted to come in contact with it.

1184. Wash to Gradually Darken the Hair. Take of sulphate of iron (green, crushed), 2 drachms avoirdupois; rectified spirit, 1 Imperial fluid ounce; oil of rosemary, 10 or 12 drops; pure soft water, $\frac{1}{2}$ pint; agitate them together until solution and mixture are complete. Many persons substitute the strongest old ale for the water ordered above. (*See No.* 1183.)

1185. Wash to Darken the Hair. Take of rust of iron, 2 drachms avoirdupois; old ale (strongest), 1 Imperial pint; oil of rosemary, 12 to 15 drops; put them into a bottle, very loosely cork it, agitate it daily for 10 or 12 days, and then, after repose, decant the clear portion for use. (*See No.* 1184.)

1186. Wash for Dry, Stubborn Hair. The best and most effective of these consists of $1\frac{1}{2}$ ounces avoirdupois glycerine dissolved in 1 Imperial pint of any fragrant distilled water, as that of roses, or orange or elder flowers; 15 to 20 grains salt of tartar (carbonate of potassa) per pint, is sometimes added.

1187. Wash to Cleanse the Hair and Scalp. 1 tea-spoonful powdered borax; 1 table-spoonful spirits of hartshorn; 1 quart soft water. Mix all together and apply to the head with a soft sponge; then rub the head well with a dry towel. Use once a week.

Another excellent method of cleansing the hair, is to take the yolk of an egg, and rub it in thoroughly a little at a time. It will produce a slight soapy lather, which should be rinsed out with soft water. This leaves the scalp perfectly clean, and the hair soft and silky.

1188. Barbers' Shampoo Mixture. Shampooing is a term used for cleansing the head and hair. Salts of tartar (carbonate of potassa) is the principal article used by barbers for this purpose. Dissolve 1 ounce salts of tartar in 1 quart soft water; sprinkle freely on the head and rub well till a lather is formed; wash off with clean water. Bay rum can then be used if desired.

1189. Shampoo Liquor. Salts of tartar, 4 ounces; pulverized borax 4 ounces; soft water, 1 gallon. Mix, and bottle for use.

1190. Fine Shampoo Liquor. This excellent wash for the hair is made by dissolving $\frac{1}{2}$ ounce carbonate of ammonia and 1 ounce borax in 1 quart water, and adding thereto 2 ounces glycerine, 3 quarts New England rum, and 1 quart bay rum. The hair, having been moistened with this liquor, is to be shampooed with the hands until a slight lather is formed; and the latter being then washed out with clear water, leaves the head clean, and the hair moist and glossy.

1191. Hair Curling Liquid. Take borax, 2 ounces; gum arabic, 1 drachm; add hot water (not boiling), 1 quart; stir, and as soon as the ingredients are dissolved add 3 table-spoonfuls strong spirits of camphor. On retiring to rest wet the hair with the above liquid, and roll it in twists of paper as usual.

1192. Curling Fluid for the Hair. Take 1 ounce avoirdupois finest white gum-arabic; good moist sugar, $\frac{1}{2}$ ounce; pure hot water, $\frac{3}{4}$ Imperial pint; dissolve. To the solution, when cold, add 2 fluid ounces rectified spirit; corrosive sublimate and powdered sal-ammoniac, each 6 grains; the last two being dissolved in the spirit before admixture. Lastly, add enough water to make the whole measure 1 pint, with a little esprit de rose, eau de Cologne, or eau de lavande, to scent it. The hair is moistened with the fluid before putting it in papers or papillotes, or twisting it with the fingers. Shake before using.

1193. **Wild Rose Curling Fluid.** Take 2 drachms avoirdupois dry salt of tartar (carbonate of potassa); powdered cochineal, ½ drachm; liquor of ammonia and esprit de rose, each 1 fluid drachm; glycerine, ½ ounce; rectified spirit, 1½ Imperial fluid ounces; distilled water, 18 ounces; digest, with agitation, for a week, and then decant or filter. The hair is moistened with it, and then loosely adjusted. The effect occurs as it dries.

1194. **Drying Washes for Moist, Lax Hair.** Take of essential oil of almonds, 1 Imperial fluid drachm; oil of cassia, ½ fluid drachm; essence of musk, ½ fluid drachm; rectified spirit, 2½ fluid ounces; mix, and add gradually, with brisk agitation, 16 avoirdupois ounces distilled water in which has been dissolved 1 ounce finest gum-arabic. The hair and scalp are slightly moistened with the liquid, and the hair at once arranged without wiping, whilst still moist. Shake before using.

1195. **Rose Bandoline.** Steep 6 ounces gum tragacanth for 30 hours in 1 gallon rose-water, stirring frequently; strain through a cloth, and let it stand for a few days; then strain again and work into it 4 drachms oil of roses. (*See No.* 1154.)

1196. **Hair Gloss.** Mix 1 pint spirit of jasmin, and 5 drops aniline, with 4 pounds pure glycerine.

1197. **How to Dry a Lady's Hair.** The lady should recline on a lounge or a sofa, with her long hair hanging over the end. A pan containing 2 or 3 bits of ignited charcoal is then placed under it, and a little powdered benzoin sprinkled upon the lighted fuel. The thick smoke which rises and is strongly impregnated with benzoic acid combined with carbonic acid, rapidly absorbs the moisture in the hair, which should be previously well wiped with towels, so as to be as free from wet as possible; and in a few seconds the hair is perfectly dry, beautifully perfumed, and ready for the operation of the brush.

Hair Dyes.

The numerous preparations vended, under different names, as hair dyes, have generally a basis of lead or silver, and possess a sameness of composition which scarcely occurs, to an equal extent, in any other class of cosmetics. A few, it is true, contain bismuth, crude pyrogallic acid, and certain astringent vegetable juices, as their active ingredients; but these are only occasionally met with in the stores.

1199. **Walnut Hair Dye.** The simplest form is the expressed juice of the bark or shell of green walnuts. This is the venerable hair dye of Paulus Ægineta. To preserve this juice, a little rectified spirit is commonly added to it, with a few bruised cloves, and the whole digested together, with occasional agitation, for a week or fortnight, when the clear portion is decanted, and, if necessary, filtered. Sometimes a little common salt is added with the same intention. It should be kept in a cool place.

1200. **Pyrogallic Hair Dye.** Take of pyrogallic acid, ¼ ounce; dissolve it in hot distilled water, 1½ ounces; and, when the solution has cooled, gradually add of rectified spirit, ½ fluid ounce. It may be made a little stronger or weaker at will.

1201. **Beautiful Black Hair Dye.** This is composed of 2 different liquids Take 6 drachms avoirdupois good recent sulphuret of potassium; distilled water, 2 Imperial fluid ounces; liquor of potassa, 1½ drachm; agitate them together, after repose decant the clear solution into a stoppered phial, and label the bottle either *Solution No.* 1, or *The Mordant.* (*See No.* 93.) This solution does not stain the skin, and is an effective and easily prepared mordant. In some of the mordants sold in the shops, the liquor of potassa is omitted. To prepare the dye, next take 3 drachms avoirdupois crystals of nitrate of silver; distilled water, 2 Imperial fluid ounces; dissolve in a stoppered phial, and mark it either *Solution No.* 2, or *The Dye.* This is the average strength of the best silver-dyes of the stores. The strongest, intended to dye the hair black, in a few cases are made with 2 drachms of the nitrate to 1 fluid ounce of distilled water; weaker ones, for brown, with only 1 drachm of the nitrate to the fluid ounce. This solution stains the skin as well as the hair. These solutions are usually put up in flat stoppered phials, and one of each, handsomely labeled, sold together in a case under various fanciful names, for which a most extravagant price is generally charged. They form the most convenient, effective, and expeditious hair dye known, and the one now chiefly sold and used by the large perfumers and hair-dressers. Other nearly similar mordants are recommended by different good authorities. A good formula is:—Take of liquor of potassa, 3 fluid drachms; hydrosulphuret of ammonia, 7 fluid drachms; distilled water, 1 ounce; mix. The method of using these liquids is given in the following receipt:

1202. **Method of Using the Hair Dye.** The hair (perfectly clean) is first thoroughly wetted to the roots with *Solution No.* 1, previously diluted with 4 or 5 times its bulk of pure water, or of the highest strength that can be used without irritating the skin, care being taken not to make the hair too wet, as that would interfere with the next operation. A small brush is commonly used for the purpose, and the action and absorption of the mordant is promoted by the free application of the former for a short time. After the lapse of 2 to 5 minutes, the hair is thoroughly but lightly moistened with the dye, or *Solution No.* 2, by means of a small-toothed comb, or what is more convenient, a half-worn tooth brush, care being taken to touch the skin as little as possible. Any stains left on the skin by accidental contact with the dye, are now removed by rubbing them with a piece of rag or sponge, or the corner of a napkin wetted with a little of the mordant previously diluted with water. After the lapse of a few minutes, the skin is sponged clean with a little warm water, and wiped dry, and the hair arranged with the comb, in the usual manner. It is better to avoid rubbing or washing the hair for a few hours. Sometimes the two operations are reversed, and the dye applied first. The color thus produced is more permanent, but stains on the skin are less easily removed. The whole process, if expertly managed, may be completed in from 10 to 15 minutes.

1203. **Hydrosulphate or Hydrosulphuret of Ammonia** (also called sulphuret or sulphide of ammonia), used as a mordant in dyeing the hair with either silver or lead, may be prepared as follows:—Take of sulphur, 1 part; fresh dry hydrate of lime, 2 parts; boil in water sufficient to dissolve the sulphur; filter, and to the filtered liquid add for every 8 parts of sulphur used, 33 parts of sulphate of ammonia. After agitation and repose, the clear supernatant liquid must be decanted, and preserved in bottles. The product contains traces of lime, which do not, however, unfit it for use in the cosmetic art. When a salt of antimony is used to dye the hair, the neutral hydrosulphuret of ammonia should be employed, as, if the liquid contain more sulphur than is necessary to neutralize the ammonia, and it be used in excess, the color at first produced is dissolved out and washed away. But if this excess be avoided, the bisulphuret gives the brightest color. The neutral hydrosulphuret is prepared by saturating strong liquor of ammonia with sulphuretted hydrogen, and then adding a second portion of liquor of ammonia equal to that first used. (*See No.* 1201.)

1204. **Red Hair Dye.** An acidulated solution of a salt of antimony (a solution of potassio-tartrate of antimony or tartar-emetic 1 to 16, acidulated with a little tartaric, citric, or acetic acid, may be used), followed by a weak mordant of neutral hydrosulphuret of ammonia (*see No.* 1203), or the bisulphuret (carefully avoiding excess) gives a red turning on the orange, which tones well on light-brown hair. A solution of sulphantimoniate of potassa (Schlippe's salt) with a mordant of water slightly acidulated with sulphuric acid, gives a bright orange-red or golden-red color.

1205. **Red Hair Dye.** A strong infusion of safflowers, or a solution of pure rouge, in a weak solution of crystallized carbonate of soda, gives a bright red like henna, or a reddish yellow, according to its strength, if followed, when dry, by a mordant of lemon juice or vinegar diluted with one-half to an equal bulk of water.

1206. **Blonde or Flaxen Hair Dye.** Mix in 10 ounces distilled water, 1 ounce acetate of iron, 1 ounce nitrate of silver, and 2 ounces nitrate of bismuth; moisten the hair with this mixture, and, after an hour, touch it with a mixture of equal parts of sulphide of potassium and distilled water.

1207. **Blonde Hair Dye.** Another method is by moistening the hair with a mixture of 2 ounces protochloride of tin and 3 ounces hydrated lime. An hour after, use the potassium solution as in last receipt.

1208. **Golden Yellow Hair Dye.** A solution of bichloride of tin, sufficiently diluted, followed by a mordant of hydrosulphuret of ammonia (*see No.* 1203), gives a rich golden yellow tint to very light hair, and a golden brown to darker hair, owing to the formation of bisulphuret of tin.

1209. **Rich Yellow Hair Dye.** A solution of acetate or nitrate of lead, followed by a mordant of yellow chromate of potash, gives a brilliant rich golden yellow. If wanted warmer or deeper toned, a few drops of solution of diacetate of lead (Goulard's extract) should be added to the acetate solution.

A solution of pure annotto obtained by boiling it in water slightly alkalized with carbonate of soda, or with salt of tartar, gives a golden yellow or flame yellow, according to its strength, to very pale hair, and corresponding tones to darker hair. A previous mordant of alum-water deepens it, and a subsequent washing with water soured with lemon juice or vinegar reddens it or turns it on the orange.

1210. **Brilliant Yellow Hair Dye.** A solution of a neutral salt of iron (sulphate, acetate, or chloride), followed by a weak solution of carbonate of soda, or salt of tartar, or lime water, gives a warm yellow or nankeen color, which, when deep, turns on the red. In the latter case it is apt to assume a sandy shade on very light hair.

1211. **Brown Hair Dye.** A ready way to color the hair brown is by a solution of permanganate of potassa in the proportion of 1 troy ounce to 1 quart of water. The hair must be first cleansed by a dilute solution of ammonia, when it is dried by means of a towel, and the solution of the permanganate applied to the hair, but not to the skin, as this would also be colored. It dyes the hair immediately, and the desired shade may be obtained by applying more or less of the solution. Should the hands become stained with it, they can be cleaned with a little dilute hydrochloric acid. This dye is not permanent, but is very easily renewed with a tooth-brush.

1212. Golden Brown Hair Dye. Brown hair may have a golden tone imparted to it by the judicious application of any of the yellow dyes already noticed. Light hair may be previously dyed of a warm light brown before applying the latter. A solution of sulphate of copper (blue vitriol), followed by a solution of ferrocyanide of potassium, gives an extremely rich golden brown or bronze brown to light hair, when the process is expertly managed.

1213. Cautions about Applying Hair Dyes. The application of the above dyes, so as to produce appropriate and agreeable shades, requires more consideration and experience than that of the black dyes. The complexion, and the natural color of the hair of the person operated on, with other attendant circumstances, must be carefully considered beforehand, and allowed for. Unless all these points be attended to, the party may, on looking in the mirror, suddenly find himself strangely altered in appearance, and probably for the worse. Hair dyes of all kinds will only act effectively and satisfactorily on perfectly clean hair. The presence or the slightest contamination of oily or greasy matter will arrest or greatly lessen their action, and render it unequal in different parts. Hence the hair, in all cases, should be first thoroughly washed with warm soap and water, then rinsed with tepid water, and lastly, wiped dry previous to their application. A few grains of soda or of salt of tartar (carbonate of potassa) added to the first water, will facilitate its detergent action.

1214. To Bleach Hair. It has been found in the case of bleaching hair that gaseous chlorine is the most effectual. The hair should be cleaned for this purpose by a warm solution of soda, and washed afterwards with water. While moist it is put into a jar and chlorine gas introduced, until the air in the jar looks greenish. Allow it to stand for 24 hours, and if necessary repeat the operation. The employment of binoxide of hydrogen has been often recommended for this purpose, it being in every way superior to the other agents, but it has the drawback of being difficult to prepare.

1215. Lotions to Change the Color of the Hair. A number of lotions are extensively advertised, and sold under the name of "Hair Restorers," "Hair Rejuvenators," "Life for the Hair," &c., which purport to restore the color and improve the growth of the hair. The active agent in all these preparations is lead, combined with sulphur, and this, by frequent application, darkens the hair. In the majority of cases, probably, a moderate use of such a lotion would be unattended with mischief; but it is worth remembering that palsy has been known to be produced by the long continued use of cosmetics containing lead. The following receipts show how these *restorers* are made:

1216. Hair Coloring which is not a Dye. Take 1 drachm lac sulphur; sugar of lead, 2 scruples; glycerine, 2 ounces; distilled water, 6 ounces; mix, and perfume to fancy. Or, lac sulphur and sugar of lead, each 1 drachm; sulphate of iron (copperas), 10 grains; glycerine, 2 ounces; water, 6 ounces; mix and perfume. Shake well before using, and apply with a sponge every other day until a change of color is obtained, after which one application each week will be sufficient. The hair must be cleansed of all greasy matter before using the above. *(See No. 1213.)*

1217. Magic Hair Colorer and Restorer. Take of sugar of lead, ¼ ounce; lac sulphur, 3 drachms; aqua ammonia, 1½ ounces; glycerine, 6 ounces; water sufficient to fill a pint bottle; mix, and perfume to suit the fancy. Or, take of lac sulphur and sugar of lead, each 1 drachm; tinctures of capsicum, and cantharides, each ¼ ounce; glycerine, 2 ounces; water, 5 ounces. Apply as above. Do not employ any greasy oils in perfuming these preparations. *(See No. 1213.)*

1218. Hair Restorative. Take 1 drachm milk of sulphur, 1 drachm acetate of lead, 2 drachms muriate of soda, 2 fluid ounces glycerine, 8 fluid ounces bay rum, 4 fluid ounces Jamaica rum, and 1 pint water. Mix together, and shake before using.

Depilatories.

Preparations for removing superfluous hair from the skin. The constituents of most of these are lime, and the tersulphuret of arsenic (orpiment), but the use of orpiment is dangerous, especially in case of any abrasion of the skin. The safest depilatory is a strong solution of sulphuret of barium made into a paste with powdered starch. It should be applied immediately after it is mixed, and allowed to remain there for 5 or 10 minutes. *(See Nos. 1223 to 1225.)*

1220. Martin's Depilatory. Apply a light coating of sulphuretted sulphide of calcium to the part from which the hair is to be removed; after 10 minutes it may be washed off, and the skin will be clean.

1221. Boudet's Depilatory. Mix 3 parts hydro-sulphuret of sodium (crystallized), 10 parts finely powdered quicklime, and 11 parts starch. It should not be applied longer than 2 to 4 minutes. Very effective and safe.

1222. Chinese Depilatory. Mix 8 ounces quicklime, 1 ounce dry pearlash, and 1 ounce sulphuret of potassium; apply as in the last receipt.

1223. To Apply a Depilatory as a Paste. In use, the chemical depilatories *(see Nos. 1219 to 1222)* which are in the state of powder, are made into a paste with warm water, and immediately applied to the part, previously shaved close, a little starch being generally added to those which do not contain it, in order to render the paste more manageable. Sometimes soap-lye is used, instead of water, to form the paste. A wooden or bone knife should be used in preparing this paste.

1224. To Apply a Depilatory as a Plaster. Another mode of application is to make the paste rather thick, spread it on a piece of strong paper, and apply it like a plaster. In from 5 to 10 or 15 minutes, or sooner if much smarting occurs, the paste should be washed off with warm water, and a little cold cream or any simple ointment applied to the part. The liquid depilatories are usually thickened with a little starch powder, before application. *(See Nos. 1219 to 1222.)*

1225. Cautions About Applying Depilatories. Both classes *(see Nos. 1223 and 1224)* require caution in their use. They should be applied to only a small surface at a time, and great care should be taken to prevent them extending to the adjacent parts. They lose their properties unless kept entirely excluded from the air; and no liquid must be added to the dry ones until just before their application, and then no more should be mixed than is required for immediate use.

Scented Oils; Perfumed Oils.

The fixed oil that usually forms the basis of the simple scented oils of the perfumer, is that of almonds, ben, or olives; but other bland vegetable oils are occasionally used, particularly for inferior qualities. In France, three different modes are adopted for imparting fragrance to these oils.

1227. Perfumed Oils by the Addition of Essential Oils, or Alcoholic Essences. By the simple addition of a sufficient quantity of the essential oil of the plant, or of the concentrated alcoholic essence of the substance, if it does not furnish an oil, followed by agitation; the whole being then allowed to repose for a few days, and, if any sediment falls (which should not be the case if the ingredients are pure), the clear portion decanted or poured off into another bottle. In the case of alcoholic essences, it is better that the fixed oil should be gently warmed by placing the bottle or vessel (a well-tinned bottle or can with a suitable mouth and neck for corking, is the best and most convenient for the purpose,) for a short time in a water-bath, before adding them, and then, after tightly and firmly securing with a cork, to agitate it until cold or nearly so. In general, 1 to 1¼ drachms of a pure essential oil, or 3 to 4 fluid drachms of a concentrated essence, is sufficient to render 1 pint of fixed oil agreeably fragrant; but in some cases, and for the best quality, an additional ½ drachm, or more, of the one, and 1 to 2 fluid drachms of the other, will be required. ½ drachm pure attar of roses, owing to the very powerful character of its odor, is sufficient for the purpose. Oils of ambergris, bergamot, cassia, cinnamon, cloves, lavender, lemons, millefleurs, musk, neroli, nutmeg, orange-flowers, roses, and all other similar scented oils, may be thus made. The above are chiefly employed as hair cosmetics, with, in most cases, trifling additions of other essential oils or essences, to modify and improve their odor. Some of them are also colored. *(Cooley.)*

1228. Perfumed Oils by Infusion. "Dry substances, after being reduced to coarse powder (but free from dust), or sliced very small; flowers or petals, after being carefully selected, picked from the stems and other scentless portions, and pulled to pieces; and soft, unctuous, and resinous matters, as ambergris, musk, civet, resins, and balsams, after being rubbed to a paste with a little of the oil (either with or without the addition of about twice or thrice their weight of clean siliceous sand or powdered glass, to facilitate the reduction), are digested in the fixed oil, for an hour or two, in a covered vessel, at a gentle heat obtained by means of a water-bath, frequent stirring or agitation being employed all the time. The vessel is then removed from the bath, and set aside (for flowers) until the next day, or (for other substances) for 5 to 7 days, to settle, when the clear portion is carefully decanted into a clean bottle, or bottles. With ambergris, civet, musk, and vanilla, the digestion, with frequent agitation, is usually continued for at least 3 weeks; and exposure of the vessel in the sun, or in some equally warm situation, is generally substituted for the heat of a water-bath. When flowers are employed, the free oil is allowed to drain off, and the remainder is obtained by the action of a press. The two portions being mixed, fresh flowers are added to the oil, and the whole process is repeated; and this again, with fresh flowers, 5 or 6 times, or oftener, until the oil is sufficiently fragrant." *(Cooley.)* For the extraction of perfume from rose leaves, from scented woods, from bark, from gums, there appears to be nothing better than glycerine, and this use of it is constantly on the increase, as the most delicate odors are perfectly preserved in it.

1229. Perfumed Oils by Enfleurage. A series of shallow iron frames, adapted for piling on each other, and fitting close together, being provided, a piece of white, spongy cotton-cloth is stretched upon each, and is then freely moistened with oil of almonds, olives, or ben. On the cloth is next laid a thin layer of the fresh-plucked flowers, and each frame, as thus covered, is placed on the preceding one, until a compact pile of them is raised. In 24 to 30 hours the flowers are replaced by fresh ones; and this is repeated every day, or every other day, until 7 or 8 different lots of flowers have been consumed, or the oil has become sufficiently charged with their odor. The cotton-cloths are then carefully collected and submitted to powerful pressure, and the expressed oil which flows from them is placed aside in corked bottles or jars, to settle. After some time it becomes perfectly clear, and is then ready to be decanted into other bottles for store or sale. Sometimes trays with perforated bottoms, on which are laid thin layers of cotton-wool slightly moistened with the oil, are substituted for the frames and cotton-cloth above referred to. Sometimes, also, sheep's wool or cotton wool impregnated with oil, is stratified with flowers in a large earthen vessel, and this, after being closely covered up, is kept for 10 or 12 hours gently heated by means of a water-bath. The next day the old flowers are replaced by fresh ones, and the whole process repeated again and again, as often as necessary. The oil is finally obtained by pressure from the wool, as before. When only a moderate degree of aroma is required in the oil, the flowers may be crushed in a mortar or a mill, with one-half their weight of blanched sweet almonds, and the next day, or the second day after, according to the weather, the mass, after being slightly warmed, may be submitted to the press. After about a week's repose, the upper portion, which is the perfumed oil, may be decanted, and, if necessary, filtered. This plan is occasionally adopted in this country for "Oil of Roses," and a few other flowers, intended for the hair. (*Cooley.*)

1230. To Perfume Hair Oils. The mixtures of essential oils, and other odorous substances, used in the preparation of the perfumed spirits, will furnish examples which may be followed in scenting hair oils and pomades, and from these can be framed other combinations as the fancy may suggest. (*See Nos.* 1243 and 1261.)

1231. Colorless Hair Oils. In preparing colorless or white hair oils, blanched fixed oil, and new and colorless, or nearly colorless, essential oils and essences only are employed.

1232. Colored Hair Oils. The colored oils derive their hues from the fixed oil of which they are prepared being tinged before the scent is added. In each case the colored oil should be allowed to clarify itself by repose in a closed vessel and a warm situation (60 to 70° Fahr.) before being decanted for further treatment. It is also better to pass it through a piece of coarse muslin, to remove floating particles; and, in some cases, it may be necessary to filter it, to render it quite brilliant—a quality which it should always possess.

1233. To Color Hair Oil Red or Crimson. A red and crimson tinge may be given by steeping, for 2 or 3 days, a little alkanet-root (say 2 or 3 drachms) in each pint of the oil. By warming the oil, the time required for obtaining the desired tinge may be reduced to 1 or 2 hours.

1234. To Color Hair Oil Yellow or Orange. A yellow and orange tinge may be given by rubbing up a little annotto with a portion of the oil whilst hot, and then adding it to the rest at a gentle heat; or, more simply, by adding a little bright palm oil to it whilst warm.

1235. To Color Hair Oils Green. A green tinge may be given by steeping a little green parsley, or spinach-leaves, or lavender, in the oil for a few days, in the cold; or by dissolving 2 or 3 drachms of gum-guaiacum in each pint of it, by the aid of heat.

1236. Oil of Musk; or Huile Musquée. Take 2 avoirdupois drachms grain-musk; ambergris, 1 drachm; oil (almond, olive, or ben), 1 Imperial pint; proceed by infusion. (*See No.* 1228.) Some makers add about 20 or 30 drops oil of lavender (English), 10 drops oil of cloves, and 5 or 6 drops oil of cassia, with the musk. A second quality is made by working over the same ingredients with ¾ pint of fresh oil.

1237. Oil of Ambergris and Musk; or Huile Royale. Take 4 drachms ambergris; grain-musk, 1 drachm; oil of lavender (English), 20 drops; oil of cassia, oil of cloves, oil of nutmeg, and neroli, each 10 drops; and proceed by infusion. (*See No.* 1228.) Very fine. The ingredients may be worked over a second time, as with oil of musk.

1238. Oil of Storax. Take 10 to 12 drachms pure liquid storax; oil of nutmeg, 12 to 15 drops; ambergris, 5 or 6 grains; oil (almond, olive, or ben), 1 Imperial pint; by infusion. (*See No.* 1228.) Highly fragrant. Used in the same way as oil of balsam of Peru.

1239. Oil of Vanilla; or Huile à la Vanille. Take 2½ ounces avoirdupois finest vanilla in powder; oil of bergamot, 1 Imperial fluid drachm; attar of roses, 15 drops; ambergris, 3 grains; oil (almond or olive), 1½ pints; by infusion. (*See No.* 1228.) Very fragrant. For the simple oil, the bergamot, attar, and ambergris, are omitted.

1240. Oil of Ambergris; Huile d'Ambergris, or Huile à l'Ambre. Take of finest ambergris, 4 to 6 drachms avoirdupois; and oil (almond, olive, or ben), 1 Imperial pint; and proceed by infusion. (*See No.* 1228.) A second quality is made by working the residuum with ¾ pint of fresh oil.

1241. Oil of Balsam of Peru. Take ½ avoirdupois ounce pure balsam of Peru, and hot oil of almonds, ¼ Imperial pint; agitate them together until perfectly mixed, and for a short time afterwards; then set the bottle aside, and in a few days decant the clear portion. Oil of nutmeg, 20 or 30 drops, is commonly added to increase its action. Used to scent other oils and fats; also, by itself, to improve and restore the hair, for which it is in high repute among many persons.

1242. Oil of Benzoin. Take finest gum benzoin, 1 ounce avoirdupois, and oil of almonds, 1 Imperial pint; and proceed by infusion. (*See No.* 1228.) Used to convey the scent of benzoin to other oils; and also to prevent rancidity.

1243. Mixed Essential Oils, or Mixed Scents. The following are used as extemporaneous scent for smelling bottles, hair oil, pomades, esprits, &c.; for which purpose one or other of them is commonly kept at hand by the druggists. 1 ounce of any one of them, added to a pint of rectified spirit, produces an agreeable esprit or perfume for personal use. Oil of bergamot and lemon, of each 1 ounce; oil of lavender (English) and pimento, of each ½ ounce; mix. Or: To the last add of oil of orange peel, 2 drachms; oil of cloves, 1 drachm; mix. Or: Take oil of bergamot, lemon and orange peel, of each 3 drachms; essence de petit-grain, 2 drachms; oil of cloves, 1½ drachms; oil of cassia, 1 drachm; mix.

1244. French Huiles or Hair Oils. The huile antique au jasmin, aux fleurs d'oranges, à la rose, à la tuberose, à la violette, &c., &c., of the French perfumers, are simply one or other of the bland fixed oils, (almonds, olives, or ben), strongly scented with the oils (huiles) of the respective flowers, or some other preparation of them. (*See Nos.* 1236 to 1242.)

1245. Marrow Oil. Take clarified beef-marrow, 1½ ounces avoirdupois; oil of almonds, ¼ Imperial pint; melt them together, and scent the mixture at will. Held in high repute as a hair oil, by many. That of the small stores has seldom any marrow in it, but lard instead. The appropriate scents are the same as for bear's grease. It is generally tinged slightly yellow by means of a little palm-oil or annotto.

1246. Tonquin Pomade or Oil. Macerate for from 12 to 24 hours, ½ pound tonquin beans in 4 pounds melted fat or warm oil, and strain through fine muslin; when cold the grease will be found to have acquired a fine odor of the beans.

1247. Vanilla Pomade or Oil. This is prepared in the same way as for tonquin beans, by substituting ¾ pound of vanilla beans.

1248. Macassar Oil. Oil of ben, 1 gallon, oil of noisette, ½ gallon; strong alcohol, 1 quart; attar of rose, 2 drachms; attar of bergamot, 3 ounces; attar of Portugal, 2 ounces; and tincture of musk, 3 ounces; mix together, digest with alkanet root (for color), in a stoppered bottle for a week, then strain and bottle.

1249. Cheap Hair Oils. These are made of fixed oils (usually almond or olive oil), gradually receding in quality, scented with less attar, the deficiency being made up by a mixture of oil of rhodium, rosemary, and bergamot. A few drops of neroli, or oil of rose geranium, or a little huile au jasmin, with or without 2 or 3 drops oil of musk or huile royale, are occasionally added to improve and slightly modify the odor.

1250. Tricopherous. Castor oil, ½ pint; 95 per cent. alcohol, ½ pint; tincture cantharides, ¼ ounce; oil of bergamot, 2 drachms. Color a pale pink with alkanet root. (*See No.* 1233.)

1251. Oil for Incipient Baldness. The commonest, and perhaps the most convenient and easily prepared cosmetic of the kind, is a mixture of equal parts of tincture of cantharides and olive oil or almond oil, simply agitated together, and shaken before use. A more effective and cleanly liquid preparation may be made by substituting proof spirit (or good rum) for the oil, and adding 1 to 1½ drachms of glycerine (Price's) to each ounce of the mixture, a corresponding increase being made in the proportion of the tincture, to compensate for this addition. This preparation imparts as much moisture and gloss to the hair as the former one, and is much more genial in its action on the scalp. Distilled water, or rosemary water, is often substituted for proof spirit. A still more active preparation is made of tincture of cantharides and glycerine only.

Pomatums or Pomades.

Any scented greasy matter of appropriate consistence, or any mixture of fats, used, or intended to be used, in dressing the hair, now commonly passes under the name of pomatum or pomade. The usual basis of ordinary pomatum or pomade for use in this climate, is either a mixture of 2 parts of hog's lard and 1 part of beef suet; or of 5 parts of lard and 2 parts of mutton suet; the fats being both previously carefully rendered or prepared, and then melted together by a gentle heat. The latter mixture is chiefly used for white pomatum or pomade. Essential oil, and other volatile matter used to scent this fat, should be added to it and stirred up with it, after it has somewhat cooled, but before it begins to solidify, in order to prevent loss. The unscented mixed fats form the plain pomade or pomatum of the perfumers. (*Cooley.*)

1253. To Purify Suet or Lard for Making Pomades. Suet or lard form the body of pomades; and that their quality may be unexceptionable, the rendered suet must be subjected to a purifying process, in order to fit it for use in perfumery. This is done by melting the rendered fat by the heat of a saline or steam bath in an enameled iron vessel, and adding to it, gradually, 1 ounce powdered alum and 2 ounces chloride of sodium (pure table salt) to every fifty pounds of fat under treatment. The heat is to be continued above 212° Fahr., until scum ceases to rise to the surface, which contains all the organic and other impurities, and must be skimmed off as fast as it is formed. The fat is then strained through bolting cloth into clean stone jars, and left to cool. It is next to be spread upon a circular stone slab, the top surface of which is slanting from the centre, (that is, slightly conical in form), and provided with a stone roller which is made to revolve by suitable gearing. As the roller, or muller, revolves over the fat, cold water is allowed to trickle upon it, and this dissolves the saline impurities remaining in the fat. After this the fat is heated until all water is expelled by evaporation. When cold, the fat will be found to be very white and pure, and in a condition to preserve its sweetness, and suitable for use with the most delicate odors.

1254. Method of Purifying Fat. Take 1 cwt. of perfectly fresh grease, either of lard or beef suet; cut the grease into small pieces, and pound it well in a mortar; when it is well crushed, wash it with water repeatedly, until, in fact, the water is as clear after withdrawing the grease as before it was put in. The grease has now to be melted over a slow fire, adding thereto about 3 ounces crystallized alum in powder, and a handful of common salt; now let the grease boil, but allow it to bubble for a few seconds only; then strain the grease through fine linen into a deep pan, and allow it to stand, to clear itself from all impurities, for about 2 hours. The clear grease is then again to be put into the pan, over a bright fire, adding thereto about 3 or 4 quarts rose water, and about 5 ounces powdered gum benzoin; it is allowed to boil gently, and all scum that rises is to be removed, until it ceases to be produced; finally the grease is put into deep pans, and when cold taken carefully off the sedimentary water; it is then fit for use, and may be kept for an indefinite period, without change or turning rancid. It will be observed that the principal feature in this process is the use of benzoin.

1255. To Perfume Melted Fat. In adding aromatics or perfumes to the melted fat, its temperature must be adapted to their relative degree of volatility. Essential oils and alcoholic essences, particularly the more delicate ones, are added at the lowest possible temperature compatible with their perfect union with the fat; whilst substances like the aromatic resins and balsams are better added to the fat more fully liquefied, aiding their solution and union by stirring the mass with a wooden, bone, or porcelain knife or spatula. With the latter, after the union is complete, it is often necessary to allow the mixture to repose for a short time, and to pour it off from the dregs before adding the essential oils and essences, and concluding the work. (*See No.* 1261.)

1256. To Finish off Pomades. In finishing off pomades two methods are adopted, according to the appearance it is desired they should have. Those which it is intended should be opaque and white, should be stirred or beaten assiduously with a knife or spatula until the fat begins to concrete, or has acquired considerable consistence, before potting it; but when it is desired that they should be transparent or crystalline, the clear liquid mass is poured into the pots or bottles, previously slightly warmed, and the whole is allowed to cool very slowly, without being disturbed, in a situation free from draughts of cold air. For the ordinary pomades a mixture of lard and suet is generally employed; for the harder ones, suet chiefly or wholly; or a little pure white wax or beeswax (according to the intended color of the product) is melted with the fat to increase its solidity. For white pomades, mutton suet is employed; for others, in general, beef suet. In those which are artificially colored, either may be used; but beef suet is preferable when either clearness or a crystalline appearance is desired. (*Cooley.*)

1257. Coloring Matters for Fat. It is often desirable, as a matter of taste, to tinge the prepared fat used for perfumery. The process given below is applicable to all fats, whether solid or fluid. Color may also be imparted by the addition of pigments in powder, but these are objectionable for pomade, hair oil, and creams. The coloring matter should be dissolved or steeped in the melting fat before scenting it. (*See No.* 1232.)

1258. To Color Fat Pink. Bruise 4 ounces alkanet root for every pound of fat used; melt the fat over a water-bath, add the bruised alkanet, and digest for several hours. Strain the mixture through bolting cloth, and allow the clear fluid fat to cool. This fat, now colored deep pink, is used as a coloring mixture; 1 ounce of it will be sufficient to color 1 pound of white fat, by simply melting them together.

1259. To Color Fat Yellow. A yellow coloring fat may be prepared as in the last receipt, by using, instead of the alkanet, 1 ounce of annotto to the pound of fat.

1260. To Color Fat Green. The same process followed in No. 1258, with fresh walnut leaves, will give a green coloring fat.

1261. Essences for Scenting Pomatums. Millefleur—oil of lemon, 3 ounces; essence of ambergris, 4 ounces; oil of cloves, 2 ounces, oil of lavender, 2 ounces. Cowslip—essence of bergamot, 16 ounces; essence of lemon, 8 ounces; oil of cloves, 4 ounces; oil of orange-peel, 2 ounces; oil of jasmin, 2 drachms; eau de bouquet, 2 ounces; oil of bitter almonds, 16 drops. For general use—essence of bergamot, 16 ounces; essence of lemon, 8 ounces; true oil of origanum and oil of cloves, each 2 ounces; oil of orange-peel, 1½ ounces. (*See Nos.* 1243 *and* 1255.)

1262. Pomades by Infusion. These are prepared by digesting the odorous substances in the simple pomade (*see No.* 1265), at a very gentle heat, for 2 or 3, to 8 or 10 hours, according to their nature, in the way already noticed under "Oils" (*see No.* 1228); observing to stir the mixture frequently, and to keep the vessel covered as much as possible during the whole time. 1 part of flowers, carefully picked and pulled to pieces, to 3 or 4 parts of pomade, are the usual proportions. The next day the mixture is again greatly heated, and, after being stirred for a short time, is thrown into a strong canvas bag, which is then securely tied, and at once submitted to the action of a powerful press. (This should have been previously made moderately warm. This is effected either by means of a steam-jacket, or by filling it with hot water. In the latter case, care should be taken to perfectly free it from water before use.) The whole operation is then repeated, several times, with fresh flowers, or other bulky odorous substance, until the pomade be sufficiently fragrant. This will require 3 to 6 times its weight in flowers. Lastly, in the case of flowers, the pomade is liquefied in a covered vessel, at a gentle heat, as before; and after sufficient repose to allow it to deposit adhering moisture, is poured off for stock, or is at once potted. *To obtain essences* the fat is treated with spirit, which combines with the essential oil, leaving the fat with still a strong odor of the flower. This latter forms the French pomade. The delicate perfume of some flowers is impaired by heat, and the process of absorption (*enfleurage*) is adopted. (*See No.* 1263.) The mode of proceeding with the aromatic barks, seeds, resins, balsams, &c., the duration of the infusion, and the proportions taken, are, for the most part, similar to those of the corresponding huiles or oils; but here the first two substances, and others of a like nature, are only bruised, ground, or sliced very small, and not reduced to actual powder before digestion, as pomades, unlike oils, cannot be freed from fine powder or dust by filtration through fine media, or by repose in the cold. In this way are prepared the pomades of balsam of Peru, benzoin, cassia, cinnamon, lavender (green), orange-blossoms, orris-root (violet), roses (colored), storax, vanilla, and several others, kept by the French perfumers, and known and spoken of in this country by their French names, as "Pomade aux Fleurs d'Oranges," "à la Rose," "à la Vanille," &c. (*Cooley.*) Piesse proposes a simple method by which any person can perfume pomade in small quantities; and, if desired, prepare perfumed extracts of favorite flowers. Procure an ordinary, perfectly clean, double glue-pot, the inner vessel capable of holding a pound of fat. When the flowers are in bloom, put a pound of fine lard into the inner vessel of the glue-pot; pour sufficient boiling water into the outer pot, and place the whole on a stove until the lard is melted; strain it through a close hair-sieve into a vessel containing cold spring water. In order to obtain a perfectly inodorous grease, this process may be repeated 3 or 4 times, using each time fresh water, containing a pinch each of salt and alum. Lastly melt the purified fat and let it cool, to free it from water. Next put the fat in a vessel in a place just warm enough to keep it constantly liquid; throw into it as many of the flowers as it will receive; every 24 hours for a week, strain the fat from the flowers, and add fresh ones. This repetition of fresh flowers will produce a highly perfumed pomade. In this manner either one kind of flowers, or a mixture of 2 or more kinds may be employed. The perfumed extract may be obtained from the pomade by introducing the cold perfumed fat, finely chopped, into a wide-necked bottle, and covering it with the strongest spirits of wine that can be obtained; and, after closing the bottle, let it stand for a week, when the spirit may be strained off, and will be a perfumed extract of the flowers employed. The following flowers are best adapted for this process: Rose, jasmin, orange, violet, jonquil, tuberose, and cassia. Piesse proposes heliotrope, but probably without sufficient grounds.

1263. Pomades by Enfleurage. These perfumed pomades are prepared by a similar process to that adopted for the corresponding oils. (*See No.* 1229.) On the large scale, a layer of simple pomade is spread, with a bone palette-knife, on panes of glass, to about the thickness of a finger, and the surface is closely stuck all over with the newly-gathered flowers. The panes are then placed in shallow frames of wood, and these are closely piled one upon another, in stacks, in a moderately cool situation. In some of the great perfumeries of France, many thousands of these frames are employed at once. On the small scale, porcelain or pewter plates are generally used instead of panes of glass, and are inverted over each other, in pairs, so as to fit close at the edges. In each case the flowers are renewed daily, and the fat stirred up and re-spread occasionally, for 1, 2, or even 3 months, or until the pomade has become sufficiently fragrant to render it of the quality intended by the manufacturer. It is now scraped off the panes or plates, into the store-pots, and is ready for use or sale. In this way are prepared the finest qualities of cowslip, honeysuckle, jasmin, jonquil, may-blossom, myrtle-blossom, narcissus, orange-flower, tuberose, and violet pomade; as well as the pomades of several other delicate flowers that readily impart their odor to fat by simple proximity or contact. The imported pomades of this class, like those of the last one, are always distinguished among the perfumers, by their French names; as "Pomade au Jasmin," "Pomade aux Fleurs d'Oranges," "Pomade à la Violette," &c. The stronger pomades of these last two classes are chiefly employed in the preparation of extraits and essences, and are added to other pomades, to impart the fragrance of the respective flowers. The others are also used as hair cosmetics. (*Cooley.*)

1264. **Mixed Pomades; Compound Pomades.** These are prepared either by the admixture of the different fragrant pomades already noticed, or by the addition of judicious combinations of the more esteemed essential oils, essences, and other odorous substances, to simple pomade, whilst in the liquid or semi-liquid state. The latter is the method almost exclusively adopted by our perfumers. The usual fatty basis of the preceding pomades is one or other of the following:

1265. **Plain Pomatum or Pomade.** Take 2 parts carefully rendered hog's lard, and 1 part beef-suet (*see No. 1253, &c.*), and melt them together by a very gentle heat. The product is of the proper consistence for temperate climates. Or: Lard, 5 parts, and mutton-suet, 2 parts. (*See No. 1253.*) Or: Lard and suet equal parts.

1266. **Common Pomatum.** Take of plain pomade (or fat), 1 pound, melt it at the lowest degree of heat that will effect the object, add of oil of bergamot and lemon, of each 1 drachm; stir the mixture until it begins to concrete, and then pour it into the pots or bottles. This forms the ordinary pomatum.

1267. **Rose Pomade.** Melt together and mix in a water-bath 1 pound prepared grease and 2 ounces spermaceti; triturate in a mortar until it becomes white and smooth, then add and incorporate thoroughly 3 ounces oil of sweet almonds, ½ drachm oil of roses, and ¼ drachm oil of geranium. A rose-color is obtained by heating the oil of almonds and adding to it ½ drachm of alkanet, and straining it before incorporation.

1268. **Pomade Millefleur.** This much esteemed pomade is strongly scented with several perfumes of the kind noticed below, so proportioned to each other that none predominate. The following are common examples; but the scents, within certain limits, may be varied at will:—Take of plain pomade, 1½ pounds avoirdupois; oil of lemon, 1½ Imperial fluid drachms; oil of lavender (English), balsam of Peru, and essence royale, of each 1 fluid drachm; oil of cassia, oil of cloves, and essence de petit-grain, of each ½ fluid drachm. Or, plain pomade, 1 pound, and essence or extrait de millefleurs, 4 to 5 fluid drachms.

1269. **Peruvian Pomade.** Take ½ ounce each good washed lard, and clarified beef suit; balsam of Peru, ¼ ounce; mix as before, add ½ fluid drachm oil of nutmeg, and pour it into pots or dumpy, wide-mouthed phials. Dr. Copland adds a little oil of lavender. In high repute as a hair-restorer.

1270. **Philocome.** This compound is made without heat. Equal parts of purified beef-marrow, oils of noisettes and sweet almonds are thoroughly mixed in a marble mortar, and the whole is then perfumed by the addition of a sufficient quantity of a mixture of extracts of rose, acacia, jasmin, orange-flower and tuberose.

1271. **Vanilla Pomatum.** Take of plain pomade 1 pound avoirdupois; melt and add 4 or 5 Imperial fluid drachms finest essence of vanilla; attar of roses, 8 or 10 drops, as before. Very fine. The plain pomade may be previously slightly tinged with annotto.

1272. **East India Pomatum; Pomade des Indes; or Pomade d'Orient.** Take beef-suet, ¾ pound avoirdupois; lard, ½ pound; pure bright beeswax, 2 ounces; finest annotto, 1 drachm; gum-benzoin in coarse powder, ¾ ounce; and grain-musk, 6 to 8 grains; digest in a covered vessel set in a water-bath, with frequent agitation, for 2 or 3 hours. After repose, decant the clear portion, add of oil of lemon, 1 Imperial fluid drachm; oil of lavender (English), ½ fluid drachm; oils of cassia, cloves and verbena, each 10 or 12 drops; and stir the mass until it has somewhat cooled. Lastly, pour it into pots or bottles, and let it cool very slowly, and undisturbed. Very fragrant.

1273. **Transparent Pomade.** Take of best transparent soap, 1½ drachms; 95 per cent. alcohol, 2½ ounces. Dissolve the soap in the alcohol by heat, and add it suddenly to a quart of hot castor oil; have perfume ready to put in at once, and pour in warm bottles. Another very superior article is prepared in the following way: Fatty oil of almonds, 2½ pounds; spermaceti, ½ pound; oil of lemon, 3 ounces. The spermaceti is melted in a water-bath, the oils are then added, and the heat kept up until a uniform mass is obtained, in which no floating particles of spermaceti can be distinguished. The pomade is then poured into glasses; if it is desired to obtain this pomade crystallized, the glasses must be heated beforehand, and cooled down very slowly.

1274. **Crystallized Pomade or Pomatum.** Take of oil of almonds or olives, 1 pint; ¾ pound spermaceti (best, pure); melt them together by a gentle heat, add scent at will, and whilst sufficiently warm to be clear, pour it into warm glass bottles, and allow it to cool very slowly, and without disturbance. Some persons add 1 drachm camphor. It is usually preferred uncolored. If tinged at all, it must be only very faintly so, and with substances that will not cause opacity.

1275. **Pomade Divine.** Take of refined beef-marrow, 1 pound avoirdupois; cypress-wood (rasped), orris root (in coarse powder), liquid styrax, of each 1 ounce; cinnamon (powdered, but not dusty), ½ ounce; cloves (well bruised), nutmegs (grated), of each ½ ounce; digest, by the heat of a water-bath, in a covered vessel, for 5 or 6 hours, and then strain through flannel. Very fine, and much esteemed for the hair, and also as an occasional skin-cosmetic.

1276. **Castor Oil Pomade; Palma-Christi Pomatum.** Take of castor oil, 1 pound avoirdupois; pure white wax, 4 ounces; melt them together, and then add of oil of bergamot, 2½ drachms; oil of lavender (English), ½ drachm; essence royale, 10 or 12 drops; stir the mixture whilst cooling.

1277. **Bear's Grease.** The fat of the bear has long been highly esteemed for promoting the growth of human hair, but without sufficient reason, since experience shows that it possesses no superiority over the fats ordinarily employed by the perfumers. Indeed, if we may regard the somewhat rank smell of genuine bear's grease as an indication of its quality, it must be inferior to them as a hair cosmetic; besides which, it is much more costly. The greater portion of the so-called bear's grease now sold is a factitious article, and is prepared by the following formula:—

1278. **Imitation Bear's Grease.** Take of washed hog's lard (dry), 1½ pounds avoirdupois; melt it by the heat of a water-bath, add of balsam of Peru, 2 drachms; flowers of benzoin and palm oil (bright), of each 1 drachm; stir vigorously for a few minutes, to promote solution. Then remove the pan from the bath, and, after repose for a short time, pour off the clear portion from the sediment, and stir the liquid mass until it begins to cool.

1279. **Pomade for Incipient Baldness.** Melt over a water-bath, 12 ounces pure veal grease, 5 ounces nerval balsam, 5 ounces nutmeg butter, and 6½ ounces oil of almonds; triturate in a mortar until thoroughly mixed; then add 10 drops croton oil, and incorporate. Next dissolve 3½ ounces subcarbonate of soda in 1 ounce each of alcohol and distilled water; incorporate this with the pomade and perfume to taste.

1280. **Cazenave's Pomade.** Prepared beef-marrow, 4 ounces (avoirdupois); tincture of cantharides, ½ fluid ounce (Imperial); and cinnamon coarsely powdered, ½ ounce; melt them together by the heat of a water-bath; stir until the spirit in the tincture has evaporated, decant the clear portion, and again stir until the mass concretes. It is cheaper and more convenient to omit the powdered cinnamon, and to strongly scent it with oil of cinnamon (or of cassia), after the removal of the vessel from the bath. Some scent it with the oils of origanum and bergamot; and others employ the oils of nutmeg and lavender for the purpose. Recommended in weak hair and remediable baldness. It is ordered to be used night and morning; the head being washed with soap and water, and afterwards with salt and water, and wiped dry, each time before applying it, or at least once a day.

1281. **Tar Pomade.** Dr. Dauvergne extolled in unmeasured terms the virtue of vegetable tar in failing hair and baldness. His formula is as follows:—6½ troy ounces lard; 5 drachms Norwegian tar; 3½ drachms each butter of nutmegs and gum-benzoin; 5 drachms fiovarenti balm; 5 drachms baume de commander; 1 ounce essence of patchouli; and 3 grains musk; mix. This formula appears unnecessarily and absurdly complicated. We have no hesitation in stating that the substitution of 3 to 5 drachms English oil of lavender, and 2 drachms essence of musk or essence royale, for the last four articles, would disguise the smell of the tar quite as well, without impairing the efficacy of the preparation.

1282. **Dupuytren's Pomade.** Take 12 avoirdupois ounces prepared beef-marrow; melt by a gentle heat, add baume nerval, 4 ounces; 3 ounces each balsam of Peru and oil of almonds; and mix thoroughly. Then add alcoholic extract of cantharides, 36 grains, dissolved in 3 Imperial fluid drachms rectified spirit; stir the mass until it concretes. This is the original formula for this celebrated pomade; but, in serious cases, Dupuytren was in the habit of doubling, or even tripling the proportion of the extract of cantharides without altering that of the other ingredients. The product is a genial stimulant and rubefacient, and, not undeservedly, has long been held in high esteem as a hair-cosmetic, acting by medicating the scalp.

1283. **Soubeiran's Pomade.** Take of oil of almonds, ½ ounce; disulphate of quinine, 1 drachm; triturate them together in a warm wedgwood ware mortar until thoroughly united; then add of prepared beef-marrow, 1½ ounces; and continue the trituration until the mass is cold. Scent may be added. Recommended for strengthening and restoring the hair.

1284. **Pomade Contre l'Alopécie, to Cure Baldness.** Fresh lemon juice, 1 drachm; extract of bark (by cold water), 2 drachms; marrow, 2 ounces; tincture of cantharides, 1 drachm; oil of lemon, 20 drops; oil of bergamot, 10 drops; mix. First wash the head with soap and water, with a little eau de Cologne, then rub it dry. Next morning rub in a small lump of pomade, and repeat it daily. In 4 or 5 weeks the cure of baldness is effected.

1285. **New French Remedy for Baldness.** Croton oil, one of the last French remedies for baldness, is employed by simply adding it to oil or pomade, and stirring or agitating the two together until admixture or solution be complete. The formula adopted by the eminent French physician who introduced this remedy, and who speaks, in the most confident and enthusiastic way, of the success attending its use, is—take of croton oil, 12 drops (minims); oil of almonds, 4 Troy drachms; mix. A little is to be well rubbed on the scalp twice a day. Soft down, we are assured, appears in three weeks. Mr. Cooley says: "I have tried a number of experiments with croton oil, thus used, in partial loss of hair and baldness, and am compelled to bear testimony to its efficacy in several apparently hopeless cases, in which even cantharidine had failed. Soft hair, resembling down, did begin to appear in from 3 to 4 weeks, and continued to grow and increase in strength for some time. It was, however, only in about one-third of these cases that this down subsequently increased in stiffness and quantity so as to well cover the part, and to deserve the name of hair, in the popular sense of the word." (*See No.* 1286.)

1286. **Caution about Strong Hair Cosmetics.** Although the stronger hair cosmetics are, as a rule, perfectly safe when applied according to the directions given, and the chief inconvenience that may arise, even from their too free or injudicious use, will be only temporary irritation, perhaps accompanied or followed by slight desquamation of the cuticle, or by a few unimportant pustules which will pass off in two or three days, yet there are cases in which their application would be unwise, and liable to produce more serious consequences. Thus, persons of a nervous temperament, with a highly irritable skin, and bad habit of body, persons liable to attacks of erysipelas, or to swollen glands behind the ears, or to swellings or tumors in the upper part of the neck behind, or to eruptive or other attacks of the scalp, and the like, should not have recourse to them. In other cases, and, indeed, in all cases, it is wise to use them very sparingly, or in a diluted state at first, and thus, as it were, feel our way, and be able to judge from experience the strength that can be employed, without inconvenience, to produce the desired effect. (*See Nos.* 1177, *&c.*, 1279, *&c.*, *and* 1285.)

1287. **Hungarian Pomade for the Moustache.** Melt by a gentle heat ½ pound gum-arabic, and ½ pound of oil soap, in 1 pint rose water, then add 1 pound white wax, constantly stirring; when of a uniform consistency, add 1 ounce attar of bergamot, and ½ drachm attar of thyme, for perfume. If required to be brown, color it with tube-burnt umber; or for black, use tube ivory-black.

Tooth Powders; Dentifrices; Poudres pour les Dents; &c.

These preparations should be compounded of materials which, while cleaning the teeth without injury to the enamel, will also be anti-acid, anti-scorbutic, and tonic in their action upon the gums. Cooley says: "Great care should be taken to finely pulverize all the dry ingredients, and to reduce the harder and gritty ones to the state of impalpable powder, either by patient levigation or trituration, or by elutriation. (*See Nos.* 25, 31, *and* 14.) To ensure the perfect mixture of the ingredients, they should be stirred together until they form an apparently homogeneous powder, which should then be passed or rubbed through a fine gauze-sieve. Those which contain volatile or perishable substances, or which, like charcoal, are affected by contact with the air, should be put up in dumpy, wide-mouthed bottles, and kept closely corked." "Tooth powders are nearly all compound powders. The only simple powder in common use as a dentifrice is powdered charcoal. Powdered bicarbonate of soda, cream of tartar, &c., are also employed, though less frequently." The following list includes some of the best tooth-powders in common use, as well as several advertised nostrums and named powders of the stores. By omitting the honey and spirit, the formulæ given for tooth pastes furnish others for tooth powders; and vice versâ. Thus, the example given under each will increase the number of the other; and both will suggest to the reader other formulæ.

1289. **Poudre Détersive Dentifrice.** Willow charcoal and white sugar in impalpable powder, each 8 ounces; calasaya bark in impalpable powder, 4 ounces; mix thoroughly in a mortar, sift through the finest bolting cloth, and perfume with a mixture of attar of mint, 2 drachms; attar of cinnamon, 1 ounce; and tincture of amber, ½ ounce.

1290. **Camphorated Chalk.** Precipitated carbonate of lime (chalk), 1 pound; powdered orris root, 3½ pounds; powdered camphor, ½ pound; reduce the camphor to fine powder by triturating it in a mortar with a little alcohol; then add the other ingredients, and when the mixture is complete, sift through the finest bolting cloth. (*See No.* 28.)

1291. **Precipitated Chalk.** This is prepared by adding a solution of carbonate of soda to a solution of chloride of calcium (both cold), as long as a precipitate forms. This last is well washed with pure water, and dried out of the dust, as the last. The refuse sulphate of lime of the soda-water makers, which is poisonous in quantity, is often sold for it by the druggists. Pure chalk is wholly soluble in vinegar, and in dilute acetic, hydrochloric, and nitric acid, with effervescence. Sulphate of lime is insoluble in these fluids.

1292. **To make Prepared Chalk.** Rub 1 pound chalk with sufficient water, added gradually, to make it a smooth cream; then stir this into a large quantity of water, after the coarser particles have settled decant the milky fluid into another vessel, and allow the chalk to settle; decant the clear water, and dry the sediment.

1293. **To Purify Hartshorn.** Burn pieces of harts' horns until perfectly white; then grind them, and purify in the same manner as chalk. (*See No.* 1292.)

1294. **Lardner's Tooth Powder.** Take of powdered charcoal (recent), 1 ounce; prepared chalk (*see No.* 1292), 3 ounces; mix, and keep it from the air. A simple, but good tooth powder, known also as *Lardner's Prepared Charcoal.*

1295. **Miahle's Rational Dentifrice.** Take of sugar of milk, 3 ounces; tannin (tannic acid), 3 drachms; red lake, 1 drachm; oil of mint and oil of aniseed, of each 7 or 8 drops; neroli, 4 or 5 drops; mix. Very serviceable in foul, lax, or bleeding gums, loose or rotten teeth, &c. As a tooth powder it is improved by the addition of 1 ounce each of burnt hartshorn and cuttle-fish bone.

1296. **Deschamp's Dentifrice for Removing the Yellow Color from Teeth.** Take of dry hypochlorite of lime, ½ drachm; red coral, 2 drachms; triturate well and mix thoroughly. This powder is employed in the following manner: a new brush is slightly moistened, then dipped in the powder and applied to the teeth. According to Deschamp, a few days' use of this powder will produce a marked alteration in the appearance of the the teeth, which will acquire a white color.

1297. **An Excellent Dentifrice.** Precipitated chalk (*see No.* 1291), 1 pound; powdered borax, ½ pound; powdered myrrh, 4 ounces; powdered orris, 4 ounces. Mix, and sift through finest bolting cloth. (*See No.* 28.)

1298. **Morfit's Dentifrice.** Powdered willow charcoal, 4 ounces; chinchona bark and sugar of milk, in powders, each 1 pound; old transparent soap, in powder, 4 ounces; mix in a marble mortar, sift through the finest bolting cloth (*see No.* 28), and perfume with attar of orange-flower, 1 ounce.

1299. **Grosvenor's Tooth Powder.** Take of red coral, 6 ounces; prepared oyster-shells, 5 ounces; orris root, 1 ounce; oil of rhodium, 4 or 5 drops; mix. This is the original formula. Equal parts of prepared shells, rose-pink, and cuttle-fish bone, are now generally substituted for the coral. It is also sold as *coral dentifrice* and *coral tooth powder.* They are all favorites in the fashionable world.

1300. **Violet Tooth Powder.** Take of precipitated chalk, 6 ounces; cuttle-fish bone, 3 ounces; rose-pink (bright), 2½ ounces; orris root, 1½ ounces; essence of violets (orris), ½ fluid drachm; indigo (pure, to strike a violet tint), a sufficient quantity; mix. A favorite dentifrice among ladies.

1301. **Areca Nut Tooth Powder.** Take of areca nut charcoal, 5 ounces; cuttle-fish bone, 2 ounces; areca nuts (raw), 1 ounce; mix. About ½ drachm each of cloves and cassia are usually added, but it is better without any such addition. Areca nut charcoal, in fine powder, is often sold under this name. This powder cannot be excelled. (*See No.* 1302.)

1302. **Areca Nut Charcoal** is prepared and kept by only a few houses; four-fifths of that sold by the druggists is spurious. The genuine powder is heavier and harder than common charcoal, and has a peculiar appearance and feel, when pressed with the fingers, which is readily distinguishable.

1303. **Pearl Dentifrice; Pearl Tooth Powder.** Take of white marble-dust, 4 ounces; cuttle-fish bone, 1 ounce; smalts (finest), 1 drachm; essence de petit-grain, 10 to 12 drops; mix. A favorite with ladies who have white, healthy teeth. Precipitated chalk or heavy carbonate of magnesia is commonly substituted for the marble-dust, but the quality of the product suffers in all but color.

1304. **Pelletier's Quinine Dentifrice.**

Take of red coral, 3 ounces; myrrh, 1 drachm; disulphate of quinine, 15 grains; scent at will; mix. Recommended as a tonic for the teeth and gums. Prepared oyster-shell is commonly substituted for the coral, and a little red bole added to color it.

Tooth Pastes; Tooth Electuaries; Pates pour les Dents.

These may consist of any of the substances ordinarily used as dentifrices, reduced to the state of impalpable powder, and beaten up with sufficient honey (liquefied by a gentle heat), syrup, or capillaire, to give them the form of a smooth and moderately stiff paste or electuary, a sufficient quantity of aromatics being usually added, as it were, to "embalm and perfume the mouth." Honey of roses is often, and conserve of roses sometimes, used for those in which their odor and color are suitable. A little rectified spirit is a useful addition, as tending to preserve them, and promote their action. A little eau de Cologne or lavender water is often employed, with the same intention. They are usually put up in porcelain or ornamental glazed earthenware pots, furnished with closely fitting covers, to preserve their contents from the air. The mixed powders should be passed through a very fine gauze-sieve, before adding the honey, and the paste should not be potted until the day following that on which it is made. (*See No.* 1288.)

1306. Ward's Tooth Paste. Take of prepared chalk (*see No.* 1292), 2 ounces; myrrh, rhatany root, and cuttle-fish bone, each, ½ ounce; orris root, ½ ounce; honey, 3 ounces. A very useful dentifrice in foul, spongy, and scorbutic gums, loose and rotten teeth, &c. This is also known as *Zeiter's Anti-scorbutic Dentifrice.*

1307. Areca Nut Charcoal Tooth Paste. Areca nut charcoal (recent, in fine powder), beaten up with pure honey or capillaire. Aromatics, though commonly added, do not improve its efficacy. (*See No.* 1302.)

1308. Areca Nut Tooth Paste. Take of recently burnt areca-nut charcoal, in fine powder (*see No.* 1302), 5 parts; raw or unburnt areca nuts, 1 part; honey, liquefied by a gentle heat, and allowed to cool, sufficient to make them into a stiff paste, adding gradually, for each ounce of the mixture, about 1 fluid drachm rectified spirit, holding in solution oil of cassia and oil of cloves, of each 10 or 12 drops. The next day beat up the mass again, adding, if necessary, a few drops of proof spirit, or of eau de rose or orange-flower water, to give it a proper consistence, and at once put it into pots. A very excellent preparation.

1309. Vanilla Tooth Paste. Take of the finest vanilla, 1 drachm; cloves, ½ drachm; lump sugar, and cuttle-fish bone, of each ½ ounce; white marble-dust, 1 ounce; mix, triturate them to an inpalpable powder, and then beat them to a paste with about 2 ounces syrup of saffron. The product is much esteemed for rapidly whitening the teeth and deodorizing the breath. 5 or 6 drops of essence of ambergris or musk, dissolved in 1 fluid drachm of rectified spirit, are often added, and improve it.

1310. Peruvian Bark Tooth Paste. This paste is made by adding 1½ or 2 drachms of Peruvian bark, in very fine powder, to the last receipt. It is a useful tonic in sponginess, foulness, and scurvy of the gums. (*See No.* 1318.)

1311. Soap Tooth Paste. Take of Castile soap (air-dried, in fine powder), and cuttle-fish bone, of each 2 ounces; honey, 4 or 5 ounces; aromatics or perfume at will, with or without the addition of a little rectified spirit. A very excellent preparation, superior to all the other pastes for cleaning the teeth and removing tartar and animalculæ from them, but inferior in blanching and preservative qualities to areca nut charcoal paste. A pink or rose color may be given it by adding 1 drachm of finely powdered cochineal, or a fluid drachm or two of the tincture. It is commonly ordered in books to be made with honey of roses, but the alkali of the soap spoils the color of this article. The above preparation is also known under the names of *Spanish Dentifrice,* and *Castilian Tooth Cream.*

1312. Violet Tooth Paste. Take of prepared chalk, 3 ounces; cuttle-fish bone and white sugar (powdered), of each, 2 ounces; orris root (powdered), 1 ounce; smalts, 2 to 3 drachms; mix with sufficient syrup of violets to make a paste. A fashionable tooth-paste, highly esteemed for its power of cleaning the teeth, and its delicate color and odor.

1313. Odontine. There are several dentifrices advertised under this name, two or three of which have acquired a very large sale in the fashionable world. That of an eminent perfumery house appears to have the following composition:—Cuttle-fish bone, Castile soap and red coral, equal parts; color with tincture of cochineal and mix with honey sufficient to make a paste, and essential oils to aromatize, a sufficient quantity of each.

1314. Pellitier's Odontine is said to consist of pulverized sepia-bone (cuttle-fish bone), with a little butter of cacao, beaten up with honey and aromatized or scented with essential oils.

1315. Magic Tooth Paste. Take of white marble-dust, 2 ounces; pumice-stone in impalpable powder, 1½ ounces; rose-pink, ½ ounce; attar of roses, 7 or 8 drops; mix as before with sufficient honey to make a paste. A favorite nostrum for rapidly cleaning and whitening the teeth, but one not adapted for free or frequent use.

1316. Charcoal Tooth Paste. Take of chlorate of potassa in very fine powder, 1 drachm; finely powdered charcoal, 2 ounces; honey (best raw, cold), 1½ ounces; sufficient mint water to flavor; form a paste as before. A rather unchemical mixture, esteemed, particularly by smokers, for deodorising the teeth and breath.

1317. To Prepare Charcoal as a Dentifrice. To prepare charcoal of the highest quality, as a dentifrice, requires considerable skill and care. The substance, whether wood or nut, should not be in larger than one inch pieces; the carbonization should be effected in covered crucibles, at a low red heat—in no case exceeding a dull cherry red,—and the whole should be cooled out of contact with the air. On opening the crucible, only those pieces should be selected for use which are properly burnt, and have a uniform dark color and a dull surface. If the heat employed be much higher than that named, the charcoal acquires a brilliant surface, and is greatly deteriorated in quality. The pieces selected should be kept in close vessels for further use or operation; any exposure to the air weakens its power of absorption.

1318. Peruvian Tooth Paste. This is formed by adding about 1½ to 2 drachms of Peruvian bark, in very fine powder, to every ounce of the dry ingredients of any simple tooth paste, before beating them up with honey or syrup. A useful tonic for tender, spongy, foul, or scorbutic gums, and said to fix loose teeth. A little powdered myrrh is sometimes added.

1319. Quinine Tooth Paste. Take red coral, 3 ounces; cuttle-fish bone, 1 ounce; disulphate of quinine, ½ drachm; mix, triturate to very fine powder, add honey (white), 4 ounces; and a few drops attar of roses, or neroli, dissolved in rectified spirit, 3 fluid drachms; and beat the whole to a paste. A little powdered myrrh (1 to 3 drachms) is sometimes added. A very fashionable and popular article. Use, &c., the same as Peruvian paste.

1320. Opiate Tooth Paste. Honey, powdered orris, and precipitated chalk (*see No.* 1291), each ½ pound; rose pink, 2 drachms. Rub into paste with simple syrup, and perfume with oils of cloves, nutmeg, and rose, each ½ ounce.

1321. Patey's Orris Tooth Paste. Take 1 pound Paris white, ½ pound rose pink, 3 ounces orris root; alum, ½ ounce; oil cloves and nutmegs, each 1 drachm. Use honey enough to form a paste.

1322. Dr. King's Tooth Paste. Prepared chalk (*see No.* 1292), 1 part; powdered Peruvian bark, 1 part; powdered old Windsor soap, 1 part. Mix with equal parts of the tinctures of rhatany and myrrh; oil of checkerberry to flavor. This paste is a fine preparation for soft, spongy gums and loose teeth.

Tooth and Mouth Washes.

These are used to rinse the mouth, and particularly the teeth and gums, a few drops, more or less, of them being added to about a wine-glassful of water for the purpose. In some cases their action is promoted by the use of the tooth-brush.

1324. Eau Botot. Tincture of cedar wood, 1 pint; tincture of myrrh and rhatany, each 4 ounces; oil of peppermint and rose, each 10 drops. Mix.

1325. Violet Mouth Wash. Tincture of orris, essence of rose, and alcohol, each ½ pint; oil of almonds, 5 drops. Mix.

1326. Mexican Tooth Wash. Take of pulverized orris root, 1 ounce; tonqua beans, 1 ounce; Peruvian bark, ½ ounce; oak bark, ½ ounce; alcohol, 1 pint; water, 1 pint; let the above stand for 12 days, and filter; color with alkanet root. An elegant tooth wash.

1327. Balm of Thousand Flowers. Take of white Castile soap, 2 ounces; honey, 4 ounces; water, 12 ounces; alcohol, 4 ounces; melt the Castile soap and honey in the alcohol and water with a gentle heat. Flavor with oil of rose and wintergreen. Used as a dentifrice.

1328. Wash to Harden the Gums. Take ½ pint of Jamaica spirits, ½ tea-spoonful each powdered alum and saltpetre pulverized, and 1 ounce of pulverized myrrh. Mix.

1329. Cologne Tooth Wash. Eau de Cologne, 1 quart; tincture of myrrh, 4 ounces. Mix.

1330. Sozodont. Take of salts of tartar (carbonate of potassa), ½ ounce; honey, 4 ounces; alcohol, 2 ounces; water, 10 ounces; oil wintergreen and oil rose, sufficient to flavor. An elegant dentifrice.

1331. Cleveland's Tooth Wash. Tinctures of myrrh, Peruvian bark, and gentian root, each 1 fluid ounce; aqua ammonia, 1 drachm; pure water, ½ pint; tincture of wintergreen, or any flavor to suit; mix. This is a fine wash for the mouth, gums, and teeth.

1332. Myrrh Tooth Wash; Kirkland's Tooth Lotion. Take of tincture of myrrh, 1 ounce; water, 2 ounces; mucilage, ½ ounce; agitate them well together, and again each time before use. As a wash in rotten and loose teeth, foul, spongy, and ulcerated gums, fetid breath, &c., it is often very serviceable where there is a scorbutic taint.

1333. Myrrh and Borax Mouth Wash. Rub well together in a mortar, 1 ounce each of borax and honey; then gradually add 1 quart spirit of wine (not above proof), and add 1 ounce each of gum myrrh and red saunders wood. Macerate for 14 days, and filter. This is an excellent wash for the gums and mouth.

1334. To Cleanse the Spaces Between the Teeth. Some dentists recommend silk floss for cleaning the spaces between teeth, but we know from experience, that No. 8 gum rings are superior. They are much more convenient in every respect.

1335. Wash to Beautify the Teeth. Dissolve 2 ounces borax in 3 pounds boiling water, and before it is cold add 1 tea-spoonful spirits of camphor, and bottle for use. A table-spoonful of this mixture, mixed with an equal quantity of tepid water, and applied daily with a soft brush, preserves and beautifies the teeth, extirpates all tartarous adhesion, arrests decay, induces a healthy action in the gums, and makes the teeth pearly white.

1336. Cachou Aromatise. These popular pastilles for perfuming the breath are thus made: Dissolve 3½ ounces extract of liquorice in 4 ounces water, by the heat of a water bath, and add pulverized gum-arabic, ¼ ounce; and Bengal catechu in powder, 1 ounce. Evaporate to the consistence of an extract, and then mix in thoroughly, powdered mastic, charcoal, cascarilla, and orris root, each ½ drachm. When the mass has been reduced to the proper consistence, it is to be removed from the fire, treated with attar of peppermint, 30 drops; tinctures of ambergris and musk, 5 drops; and then poured out upon an oiled slab, and rolled to a very thin sheet. After cooling, blotting paper is pressed upon it to absorb any adhering oil, and the surfaces are moistened with water, and covered with silver leaf. When dry it is to be divided into small bits of the size of a lentil.

Syrups for Soda or Mineral Waters.

The following is a collection of well approved receipts for flavoring mineral waters, selected principally from the "Druggist's Circular and Chemical Gazette." Most of the syrups not made from fruits may have a little gum-arabic added, in order to produce a rich froth when the soda water is added.

1385. Simple Syrup. To 8 pounds finest white sugar, add 2 quarts water and the whites of 2 eggs; stir until all the sugar is dissolved; simmer for 2 or 3 minutes; skim well, and strain through a fine flannel bag. The following syrups for soda water may be produced by employing the above syrup as a basis. A variety of other syrups may be made in the same way by using the artificial fruit essences. (*See No.* 1045, *also last receipt.*)

1386. Simple Syrup. White sugar, 10 pounds; water, 1 gallon; isinglass (best), ½ ounce (or, the white of an egg). Dissolve the isinglass in hot water, and add it to the hot syrup. The syrup is to be made with gentle heat, and then strained.

1387. Lemon Syrup. Add to simple syrup, when cold, 20 drops fresh oil of lemon and ½ ounce citric acid (previously dissolved in 3 ounces water) to each gallon. Mix by shaking well in a bottle, then add 4 ounces gum solution, made by dissolving 2 ounces fine white gum-arabic in 2 ounces warm water.

1388. Lemon Syrup. Grate off the yellow rind of lemons, and beat it up with a sufficient quantity of granulated sugar. Express the lemon juice, add 1 pint water to each pint of juice and 3½ pounds granulated sugar, including that rubbed up with the rind; warm until the sugar is dissolved, and strain.

1389. Sarsaparilla Syrup. To 1 gallon simple syrup add 10 drops oil of anise, 20 drops oil of wintergreen, 20 drops oil of sassafras, and 6 ounces caramel, or coloring. Before the oils are added to the syrup, they should be cut by grinding them in a mortar, with as much sugar as they will moisten, or mixed with a small quantity of strong alcohol.

1390. Sarsaparilla Syrup. Take oil of wintergreen, 10 drops; oil of anise, 10 drops; oil of sassafras, 10 drops; fluid extract of sarsaparilla, 2 ounces; simple syrup, 5 pints; powdered extract of liquorice, ½ ounce; mix well.

1391. Parrish's Syrup of Sarsaparilla for Mineral Waters. Take simple syrup, 4 pints; compound syrup of sarsaparilla, 4 fluid ounces; caramel, 1½ ounces; oil of wintergreen, 6 drops; oil of sassafras, 6 drops; mix.

1392. Ginger Syrup. Bruised Jamaica ginger, 2 ounces; boiling water, 1 pint; macerate for 4 hours; add fine white sugar, 2 pounds, and strain through a fine flannel bag. Ginger syrup may also be made by adding 2 ounces extract of ginger to 1 gallon simple syrup.

1393. Ginger Syrup. Tincture of ginger, 2 fluid ounces; simple syrup, 4 pints; mix.

1394. Vanilla Syrup. Vanilla, 6 drachms; boiling water, 4½ pints; sugar, 4 pounds avoirdupois. Reduce the vanilla to fine powder by trituration with a portion of the sugar; boil this with water for 2 hours in a covered vessel, then strain.

1395. Vanilla Syrup. Fluid extract of vanilla, 1 ounce; citric acid, ¼ ounce; simple syrup, 1 gallon; rub the acid with some of the syrup, add the extract of vanilla, and mix.

1396. Wild Cherry Syrup. Steep 4 ounces wild cherry bark, well bruised, in 1 pint cold water, for 36 hours; press out the infusion; let it stand till clear; decant, and add 1½ pounds fine white sugar; mix and strain.

1397. Wild Cherry Syrup. Moisten 5 ounces wild cherry bark, in coarse powder, with water, and let it stand for 24 hours in a close vessel. Then pack it firmly in a percolator, and pour water upon it until 1 pint of fluid is obtained. To this add 28 ounces sugar.

1398. Strawberry Syrup. Take fresh strawberries and inclose them in a coarse bag; press out the juice, and to each quart add 1 pint water and 6 pounds white sugar; dissolve by raising it to the boiling point, and strain; bottle and cork hot, and keep in a cool place.

1399. Strawberry Syrup. Take fresh strawberries, 5 quarts; white sugar, 12 pounds; water, 1 pint. Sprinkle some of the sugar over the fruit in layers, and allow the whole to stand for several hours; express the juice and strain, washing out the pulp with water; add the remainder of sugar and water, bring the fluid to the point of boiling, and then strain. This will keep for a long time.

1400. Strawberry Syrup. Strawberry juice, 1 pint; simple syrup, 3 pints; solution of citric acid (*see Fruit Acid*), 2 drachms; mix.

1401. Fruit Acid (used in some of the syrups). Citric acid, 4 ounces; water, 8 ounces.

1402. Strawberry Syrup Without the Fruit. Add to 1 gallon simple syrup, 2 tea-spoonfuls essence of strawberry, and ½ ounce tartaric acid. Color with coloring made as follows: Boil 1 ounce cochineal with ½ tea-spoonful of cream of tartar. Strain.

1403. Raspberry Syrup. Make as directed for strawberry syrup, either with the fruit or the essence. The flavor of this syrup is improved by using 1 pint currants to 5 of raspberries.

1404. Blackberry Syrup. Make as directed for strawberry, and add to each quart 1 ounce of the best French brandy.

1405. Pineapple Syrup. Take a convenient number of pineapples, pare and mash them in a marble or porcelain mortar, with a small quantity of sugar; express the juice, and for each quart take 1½ pints water and 6 pounds fine sugar; boil the sugar and water, then add the juice; remove from the fire, and skim and strain. Or make it with the essence, as directed for strawberry. (*See No.* 1402.)

1406. Pineapple Syrup. Oil of pineapple, 1 drachm; tartaric acid, 1 drachm; simple syrup, 6 pints; mix. Or: Take 1 gallon expressed pineapple juice; sugar, 15 pounds; fruit acid (*see No.* 1401), 2 ounces; mix.

1407. Wintergreen Syrup. Oil of wintergreen, 25 drops; simple syrup, 5 pints; sufficient burnt sugar to color (*see No.* 694); mix.

1408. Maple Syrup. Take maple sugar, 4 pounds; water, 2 pints.

1409. Chocolate Syrup. Mix 8 ounces chocolate in 2 pints water, and stir thoroughly over a slow fire. Strain, and add 4 pounds white sugar.

1410. Orange Syrup. Take a convenient number of fresh and ripe oranges, grate off the outside yellow peel; cut the oranges and express the juice; and to each quart add 1 pint water and 6 pounds sugar, previously well mixed with the grated peel. Dissolve by gentle heat, then strain.

1411. Pear Syrup. Make as directed for pineapple syrup, or use the essence of pear, by adding to each gallon of simple syrup 2 tea-spoonfuls essence of pear and ½ ounce of tartaric acid.

1412. Apple Syrup. Make as directed for pineapple syrup; or with the appropriate fruit essence and acid, as above.

1413. Banana Syrup. Make as directed for pineapple syrup; or with the appropriate fruit essence, as before directed. (*See No.* 1402.) Or: Take oil of banana, 2 drachms; tartaric acid, 1 drachm; simple syrup, 6 pints; mix.

1414. Grape Syrup. Brandy, ½ pint; spirits of lemon, ¼ ounce; tincture of red saunders, 2 ounces; simple syrup, 1 gallon. Mix.

1415. Orgeat Syrup. Take 3 ounces sweet almonds and ½ ounce bitter almonds; gum-arabic in powder, ½ ounce; sugar in powder, 3 ounces. Rub together in a mortar, adding water from time to time, until the mixture measures 1 quart. Strain through a cloth, and mix with 1 gallon of simple syrup.

1416. Imitation Orgeat Syrup. Cream syrup, 1 pint; vanilla syrup, 1 pint; oil of bitter almonds, 4 drops. Or: About 2 drachms imitation cream syrup (*see No.* 1430) are to be mixed with 2 ounces simple syrup and flavored with bitter almond and orange-flower waters.

1417. Orange-Flower Syrup. Add to 1 gallon simple syrup ½ ounce extract of orange flowers.

1418. Coffee Syrup. Coffee, roasted, ½ pound; boiling water, 1 gallon. Enough is filtered to make ½ gallon of the infusion, to which add granulated sugar, 7 pounds.

1419. Nectar Syrup. Strawberry syrup, ¼ pint; Madeira wine, 1 ounce; orgeat syrup,

½ pint. Mix.

1420. Nectar Syrup. Vanilla syrup, 5 pints; pineapple syrup, 1 pint; strawberry, raspberry, or lemon syrup, 2 pints. Mix.

1421. Sherbet Syrup. Vanilla syrup, 3 pints; pineapple syrup, 1 pint; lemon syrup, 1 pint. Mix.

1422. Ambrosia Syrup. Raspberry syrup, 2 pints; vanilla syrup, 2 pints; Hock wine, 4 ounces. Mix.

1423. Hock and Claret Syrup. Hock or claret wine, 1 pint; simple syrup, 2 pints. Mix.

1424. Solferino Syrup. Brandy, 1 pint; simple syrup, 2 pints. Mix.

1425. Cream Syrups. These are prepared by mixing highly flavored syrups with fresh cream. As this latter does not keep well, it is a more economical plan to make a simple cream syrup in suitable quantities, and to add a portion of it to the flavored syrup as required. This prevents the loss of different flavored syrups by spoiling, and allows of the cream being used for any flavored syrup.

1426. Simple Cream Syrup. Mix together thoroughly 1 pound powdered sugar with 1 pint fresh cream. Keep it in pint bottles for use.

1427. Taylor's Cream Syrup. Fresh cream, ½ pint; fresh milk, ½ pint; powdered sugar, 1 pound. Mix by shaking, and keep in a cool place. The addition of a few grains of bicarbonate of soda will for some time retard souring.

1428. Hubbell's Cream Syrup. This is prepared with 1½ pounds sugar to 1 pint of cream.

1429. Cream Syrup. Take of fresh cream, 1 pint; fresh milk, 1 pint; fine powdered sugar, 3 pounds; beat the sugar with the milk and the whites of 2 eggs, then mix with the cream. Flavor with vanilla, lemon, or strawberry. Keep in a cool place, well bottled.

1430. Imitation Cream Syrup. Make an emulsion with 3 fluid ounces fresh oil of sweet almonds, 2 ounces powdered gum-arabic, and 9 ounces water; then dissolve 1 pound white sugar by a gentle heat, strain, and when cool, add the whites of 2 eggs. It should be put up in small bottles, well corked, in a cool place. This is not only an excellent imitation and substitute for cream syrup, but will keep well for a considerable time.

1431. Cream Syrup. Take of fresh unskimmed milk, 1 pint; sugar, 2 pounds, Troy. Dissolve by shaking in a bottle, add ¼ of this to ¾ of any of the fruit syrups; or, for vanilla cream, add about a table-spoonful of fluid extract of vanilla to 1 pint.

1432. Vanilla Cream Syrup. Fluid extract of vanilla, 1 ounce; simple syrup, 3 pints; cream (or condensed milk), 1 pint. May be colored with carmine.

1433. Coffee Cream Syrup. Coffee syrup, 2 pints; Cream, 1 pint.

1434. Nectar Cream Syrup. This is a mixture of 3 parts vanilla syrup, 1 part pineapple syrup, 1 part lemon syrup, and 1 part simple cream syrup.

Cements and Uniting Bodies.

In the preparation of cements and all substances intended to produce close adhesion, whether in a semi-fluid or pasty state, freedom from dirt and grease is a most essential and necessary condition. Quite as much depends upon the manner in which a cement is applied as upon the cement itself. The best cement that ever was compounded would prove entirely worthless if improperly applied. The preparations given below will be found to answer every reasonable demand; and if properly prepared and used strictly according to the directions laid down, will seldom fail to form a union as strong, if not stronger than the substances joined. The first point that demands attention, is to bring the cement itself into intimate contact with the surface to be united. This end is best reached, when using hot cements, by making the edges to be joined at least as hot as the cement when applied, or as nearly so as can be done without injury to the substance; in some cases it is even preferable to melt the cement on the heated edges. Another very important point is to use as little cement as possible. When the surfaces are separated by a large mass of cement, we have to depend upon the strength of the cement itself, and not upon its adhesion to the surfaces which it is used to join; and, in general, cements are comparatively brittle. Sealing-wax is a very good agent for uniting metal to glass or stone, provided the masses to be united are made so hot as to fuse the cement; but if the cement is applied to them while they are cold, it will not stick at all. This fact is well known to venders of cement for uniting earthenware. By heating two pieces, so that they will fuse shellac, they are able to join them so that they will rather break at any other part than along the line of union. But although people constantly see the operation performed, and buy liberally of the cement, it will be found in nine cases out of ten the cement proves worthless in their hands, simply because they do not know how to use it. They are afraid to heat a delicate glass or porcelain vessel to a sufficient degree, and they are apt to use too much of the material, and the result is a failure; the cement is consequently deemed good for nothing. The great obstacles to the junction of any two surfaces are air and dirt. The former is universally present, the latter is due to accident or carelessness. All surfaces are covered with a thin adhering layer of air which it is difficult to remove, and unless this is displaced, the cement cannot adhere to the surface to which it is applied, simply because it cannot come into contact with it. The most efficient agent in displacing this adhering air is heat. Metals warmed to a point a little above 200° become instantly and completely wet when immersed in water. Hence, for cements that are used in a fused condition, heat is the most efficient means of bringing them in contact with the surfaces to which they are to be applied. In the case of glue, the adhesion is best attained by moderate pressure and friction.

2152. Armenian or Jeweler's Cement. The following is a receipt for a strong cement used by some oriental nations, for the purpose of attaching precious stones to metallic surfaces: Take 6 pieces of gum mastic, the size of a pea, and dissolve them in the smallest possible quantity of 95 per cent. alcohol. Soften some isinglass in water (though none of the water must be used), and saturate strong brandy with it till you have 2 ounces of glue; then rub in 2 small pieces of gum ammoniac. Mix the two preparations at a heat. Keep well stoppered. Set the bottle in hot water before using. It is said by the Turks that this preparation will unite two metallic surfaces, even of polished steel.

2153. Keller's Armenian Cement for Glass, China, &c. Soak 2 drachms cut isinglass in 2 ounces water for 24 hours; boil down to 1 ounce; add 1 ounce spirit of wine, and strain through linen. Mix this, while hot, with a solution of 1 drachm mastic in 1 ounce rectified spirit, and triturate thoroughly with ½ drachm powdered gum ammoniac.

2154. Ure's Diamond Cement. Take 1 ounce isinglass and 6 ounces distilled water; boil down to 3 ounces; add 1½ ounces rectified spirit. Boil for 2 minutes, strain, and add, while hot, ½ ounce of a milky emulsion of ammoniac, and 5 drachms tincture of gum mastic.

2155. Chinese Cement. Take of orange shellac, bruised, 4 ounces; highly rectified spirit of wine, 3 ounces. Set the mixture in a warm place, frequently shaking it till the shellac is dissolved. Wood naphtha may be substituted for the spirit of wine, but the unpleasant smell of the naphtha is some objection.

2156. To Mend Broken Glass. A much better process for mending broken glass, china and earthenware with shellac, than heating them, is to dissolve the shellac in alcohol to about the consistence of molasses, and with a thin splinter of wood or pencil-brush touch the edges of the broken ware. In a short time it sets without any heating, which is often inconvenient. It will stand every contingency but a heat equal to boiling water.

2157. To Mend Crockery Ware. One of the strongest cements and easiest applied for this purpose is lime and the white of an egg. To use it, take a sufficient quantity of the egg to mend one article at a time, shave off a quantity of lime, and mix thoroughly. Apply quickly to the edges and place firmly together, when it will very soon become set and strong. Mix but a small quantity at once, as it hardens very soon, so that it cannot be used. Calcined plaster of Paris would answer the same purpose.

2158. Badigeon. A cement used by operatives and artists to fill up holes and cover defects in their work. Statuaries use a mixture of plaster and free-stone for this purpose; carpenters, a mixture of sawdust and glue, or of whiting and glue; coopers use a mixture of tallow and chalk. The same name is given to a stone colored mixture used for the fronts of houses, and said to be composed of wood-dust and lime slacked together, stone-powder, and a little umber or sienna, mixed up with alum water to the consistence of paint.

2159. Japanese Cement. Intimately mix the best powdered rice with a little cold water, then gradually add boiling water until a proper consistence is acquired, being particularly careful to keep it well stirred all the time; lastly, it must be boiled for one minute in a clean sauce-pan or earthen pipkin. This glue is beautifully white and almost transparent, for which reason it is well adapted for fancy paper work, which requires a strong and colorless cement.

2160. Curd Cement. Add ½ pint vinegar to ½ pint skimmed milk. Mix the curd with the whites of 5 eggs well beaten, and sufficient powdered quick-lime sifted in with constant stirring, so as to form a paste. It resists water, and a moderate degree of heat, and is useful for joining small pieces of marble or alabaster.

2161. To Make a Cement that will Resist Benzine and Petroleum. It has quite recently been discovered that gelatine mixed with glycerine yields a compound liquid when hot, but which solidifies on cooling, and forms a tough, elastic substance, having much the appearance and characteristics of India rubber. The two substances united form a mixture entirely and absolutely insoluble in petroleum or benzine, and the great problem of making casks impervious to these fluids is at once solved by brushing or painting them on the inside with the compound.

This is also used for printers' rollers and for buffers of stamps, as benzine or petroleum will clean them when dirty in the most perfect manner and in an incredibly short space of time. Water must not be used with this compound.

2162. Cement to Resist Petroleum. A cement peculiarly adapted to stand petroleum or any of its distillates is made by boiling 3 parts resin with 1 caustic soda and 5 water. This forms a resin soap which is afterward mixed with half its weight of plaster of Paris, zinc white, white lead, or precipitated chalk. The plaster hardens in about 40 minutes.

2163. Cement for Aquaria. Mix 3 pounds well dried venetian red (finely powdered) with 1 pound oxide of iron, and add as much boiling oil as will reduce it to a stiff paste.

2164. Cement for Marine Aquaria. Take 10 parts by measure litharge, 10 parts plaster of Paris, 10 parts dry white sand, 1 part finely powdered resin, and mix them, when wanted for use, into a pretty stiff putty with boiled linseed oil. This will stick to wood, stone, metal, or glass, and hardens under water. It is also good for marine aquaria, as it resists the action of salt water. It is better not to use the tank until 3 days after it has been cemented.

2165. Water Cement. Manganese is found to be a valuable ingredient in water cements. 4 parts gray clay are to be mixed with 6 parts black oxide of manganese, and about 90 parts good lime stone reduced to fine powder, the whole to be calcined to expel the carbonic acid; when well calcined and cooled, to be worked into the consistence of a stiff paste, with 60 parts washed sand.

2166. Cement for Glass Syringes. Take pitch, 2 parts; gutta percha, 1 part; melt together over a slow fire, apply hot, and trim with a hot knife.

2167. Quickly-Setting Rust Joint Cement. Make into a paste with water 1 part by weight sal ammoniac in powder, 2 parts flower of sulphur, and 80 parts iron borings.

2168. Slowly-Setting Rust Joint Cement. Make into a paste with water, 2 parts sal ammoniac, 1 part flower of sulphur, and 200 parts iron borings. This cement is better than the last if the joint is not required for immediate use.

2169. Red Lead Cement for Face Joints. Mix 1 part each white and red lead with linseed oil to the proper consistence.

2170. Singer's Cement for Electrical Machines and Galvanic Troughs. Melt together 5 pounds resin, and 1 pound bees' wax, and stir in 1 pound red ochre (highly dried, and still warm), with 4 ounces Paris plaster, continuing the heat a little above 212° and stirring constantly till all frothing ceases. Or, (for troughs), resin, 6 pounds; dried red ochre, 1 pound; calcined plaster of Paris, ½ pound; linseed oil, ¼ pound.

2171. Cement for Rooms. M. Sarel, of Paris, has made an invention which is pronounced better than plaster of Paris for coating the walls and ceilings of rooms. A coat of oxide of zinc, mixed with size, made up like a wash, is first laid on, and over that a coat of chloride of zinc applied, prepared in the same way as the first wash. The oxide and chloride effect an immediate combination, and form a kind of cement, smooth and polished as glass, and possessing the advantages of oil paint without its disadvantages of smell.

2172. Coppersmith's or Blood Cement. Bullock's blood thickened with finely powdered quicklime makes a good cement to secure the edges and rivets of copper boilers, to mend leaks from joints, &c. It must be used as soon as mixed, as it rapidly gets hard. It is extremely cheap and very durable, and is suited for many purposes where a strong cement is required.

2173. Pew's Composition for Covering Buildings. Take the hardest and purest limestone (white marble is to be preferred), free from sand, clay, or other matter; calcine it in a reverberatory furnace, pulverize, and pass it through a sieve. 1 part, by weight, is to be mixed with 2 parts clay well baked and similarly pulverized, conducting the whole operation with great care. This forms the first powder. The second is to be made of 1 part calcined and pulverized gypsum, to which is added 2 parts clay, baked and pulverized. These two powders are to be combined, and intimately incorporated, so as to form a perfect mixture. When it is to be used, mix it with about a fourth part of its weight of water, added gradually, stirring the mass well the whole time, until it forms a thick paste, in which state it is to be spread like mortar upon the desired surface. It becomes in time as hard as stone, allows no moisture to penetrate, and is not cracked by heat. When well prepared it will last any length of time. When in its plastic or soft state, it may be colored of any desired tint.

2174. Hard Hydraulic Cement. A cement which is said to have been used with great success in covering terraces, lining basins, cementing stones, etc., resisting the filtration of water, and so hard that it scratches iron, is formed of 63 parts well-burned brick, and 7 parts litharge, pulverized and moistened with linseed oil. Moisten the surfaces to which it is to be applied.

2175. Universal Cement. Dissolve 2 ounces mastic in just enough 95 per cent. alcohol to effect a solution. Then soak 2 ounces isinglass, or fish-glue until it is thoroughly softened. Dissolve the isinglass in proof spirits sufficient to form a strong glue, and then add 1 ounce finely pulverized gum ammoniac. Warm the two mixtures together over a slow fire, and when they are thoroughly mixed, bottle and hermetically seal them. This cement becomes perfectly dry in 12 or 15 hours. When the cement is to be used, the bottle should be heated in a water bath to liquefy it; the fragments to be cemented should also be heated before joining them, and, as a matter of course, the surfaces well cleaned. Glass, crockery, &c., restored by the above cement, are as solid as before having been mended, and the seams are scarcely visible.

2176. To Cement Amber. Amber is joined or mended by smearing the surfaces with boiled linseed oil, and strongly pressing them together, at the same time holding them over a charcoal fire or heating them in any other way that will not injure the amber.

2177. To Cement Alabaster and Plaster. Ornaments of alabaster or plaster may be joined together by means of a little white of egg, thickened with finely-powdered quicklime, or by a mixture of newly-baked and finely-powdered plaster of Paris, mixed up with the least possible quantity of water.

2178. Mending Plaster Models. Wax and resin, or shellac varnish, is recommended for the above purpose. Dr. Chaim suggests the use of liquid silex. Wet the two surfaces with it, and allow a few moments to dry. It will be found very useful in cases of accident to a cast.

2179. Waterproof Mastic Cement. Mix together 1 part red lead to 5 parts ground lime, and 5 parts sharp sand, with boiled oil. Or: 1 part red lead to 5 whiting and 10 sharp sand mixed with boiled oil.

2180. Marble Workers' Cement. Flower of sulphur, 1 part; hydrochlorate of ammonia, 2 parts; iron filings, 16 parts. The above substances must be reduced to a powder, and securely preserved in closely stopped vessels. When the cement is to be employed, take 20 parts very fine iron filings, add 1 part of the above powder, mix them together with enough water to form a manageable paste. This paste solidifies in 20 days and becomes as hard as iron.

2181. Masons' Cement for Coating the Insides of Cisterns. Take equal parts of quicklime, pulverized baked bricks, and wood ashes. Thoroughly mix the above substances, and dilute with sufficient olive oil to form a manageable paste. This cement immediately hardens in the air, and never cracks beneath the water.

2182. Colored Cements. Professor Boettger prepares cement of different colors and great hardness by mixing various bases with soluble glass. Soluble soda glass of 33° Baumé is to be thoroughly stirred and mixed with fine chalk, and the coloring matter (*see 12 following receipts*) well incorporated. In the course of 6 or 8 hours a hard cement will set, which is capable of a great variety of uses. As soluble glass can be kept on hand in liquid form, and the chalk and coloring matters are permanent and cheap, the colored cements can be readily prepared when wanted, and the material can be kept in stock, ready for use, at but little expense. Boettger recommends the following coloring matters:

2183. Black Cement. Well sifted sulphide of antimony, mixed with soluble glass and chalk (*see No.* 2182), gives a black mass, which, after solidifying, can be polished or burnished with agate, and then possesses a fine metallic lustre.

2184. Grey-Black Cement. Fine iron dust, mixed as in No. 2182, gives a grey-black cement.

2185. Grey Cement. Zinc dust. This, used as in No. 2182, makes a grey mass, exceedingly hard, which, on polishing, exhibits a brilliant metallic lustre of zinc, so that broken or defective zinc castings may be mended and restored by a cement that might be called a cold zinc casting. It adheres firmly to metal, stone, and wood.

2186. Bright Green Cement. Carbonate of copper, used according to No. 2182, gives a bright green cement.

2187. Dark Green Cement. Sesquioxide of chromium, mixed as in No. 2182, gives a dark green cement.

2188. Blue Cement. Thénard's blue, used as in No. 2182, makes a blue cement.

2189. Yellow Cement. Litharge, with soluble glass, &c., see No. 2182, gives a yellow cement.

2190. Bright Red Cement. Cinnabar, used as directed in No. 2182, makes a bright red cement.

2191. Violet Red Cement. Carmine, used as in No. 2182, yields a violet red cement.

2192. White Cement. The soluble glass with fine chalk alone (*see No.* 2182) gives a white cement of great beauty and hardness.

2193. Black Cement. Sulphide of antimony and iron dust, in equal proportions, stirred in with soluble glass (*see No.* 2182), afford an exceedingly firm black cement.

2194. Dark Grey Cement. Zinc dust and iron in equal proportions, used as in No. 2182, yield a hard dark grey cement.

2195. Portland Cement. Portland cement is formed of clay and limestone, generally containing some silica, the properties of which may vary without injury to the cement. The proportion of clay may also vary from 19 to 25 per cent. without detriment. The only necessary condition for the formation of a good artificial Portland cement, is an intimate and homogeneous mixture of carbonate of lime and clay, the proportion of clay being as above stated. The materials are raised to a white heat in kilns of the proper form, so that they are almost vitrified. After the calcination all pulverulent and scorified portions are carefully pricked out and thrown away. The remainder is then finely ground and becomes ready for use. The amount of water which enters into combination with it in mixing is about .366 by weight. It sets slowly, from 12 to 18 hours being required. Made into a thin solution like whitewash, this cement gives woodwork all the appearance of having been painted and sanded. Piles of stone may be set together with common mortar, and then the whole washed over with this cement, making it look like one immense rock of grey sandstone. For temporary use a flour-barrel may have the hoops nailed, and the inside washed with a little Portland cement, and it will do for a year or more to hold water. Boards nailed together, and washed with it, make good hot-water tanks. Its water-resisting properties make it useful for a variety of purposes.

2196. Mastic Cements, or Pierre Artificielle. Boettger says that these cements are mixtures of 100 parts each of sand, limestone, and litharge, with 7 parts linseed oil. These ingredients, carefully mixed and well worked together, will have the consistency of moist sand, and at first but little coherence. When pressed, however, the mixture gradually acquires the hardness of ordinary sandstone, and in six months time will emit sparks when struck with steel. The binding agents in such cements are the litharge and oil, the sand giving the body, and limestone or chalk filling up the interstices.

2197. Coarse Stuff for Plastering. Coarse stuff, or lime and hair, as it is sometimes called, is prepared in the same way as common mortar, with the addition of hair procured from the tanner, which must be well mixed with the mortar by means of a three-pronged rake, until the hair is equally distributed throughout the composition. The mortar should be first formed, and when the lime and sand have been thoroughly mixed, the hair should be added by degrees, and the whole so thoroughly united that the hair shall appear to be equally distributed throughout.

2198. Fine Stuff for Plastering. This is made by slacking lime with a small portion of water, after which sufficient water is added to give it the consistence of cream. It is then allowed to settle for some time, and the superfluous water is poured off, and the sediment suffered to remain till evaporation reduces it to a proper thickness for use. For some kinds of work it is necessary to add a small portion of hair.

2199. Stucco for Inside of Walls. This stucco consists of 3 parts fine stuff (*see No.* 2198) and 1 part fine washed sand. Those parts of interior walls which are intended to be painted are finished with this stucco. In using this material, great care must be taken that the surface be perfectly level, and to secure this it must be well worked with a floating tool or wooden trowel. This is done by sprinkling a little water occasionally on the stucco, and rubbing it in a circular direction with the float, till the surface has attained a high gloss. The durability of the work much depends upon how it is done, for if not thoroughly worked it is apt to crack.

2200. Gauge Stuff. This is chiefly used for mouldings and cornices which are run or formed with a wooden mould. It consists of about ½ plaster of Paris, mixed gradually with ¾ fine stuff. (*See No.* 2198.) When the work is required to set very expeditiously, the proportion of plaster of Paris is increased. It is often necessary that the plaster to be used should have the property of setting immediately it is laid on, and in all such cases gauge stuff is used, and consequently it is extensively employed for cementing ornaments to walls or ceilings, as well as for casting the ornaments themselves.

2201. Higgins' Stucco. To 15 pounds best stone lime add 14 pounds bone ashes, finely powdered, and about 95 pounds clean, washed sand, quite dry, either coarse or fine, according to the nature of the work in hand. These ingredients must be intimately mixed, and kept from the air till wanted. When required for use, it must be mixed up into a proper consistence for working with lime water, and used as speedily as possible.

2202. Durable Composition for Ornaments. This is frequently used, instead of plaster of Paris, for the ornamental parts of buildings, as it is more durable, and becomes in time as hard as stone itself. It is of great use in the execution of the decorative parts of architecture, and also in the finishings of picture frames, being a cheaper method than carving, by nearly 80 per cent. It is made as follows: 2 pounds best whitening, 1 pound glue, and ½ pound linseed oil are heated together, the composition being continually stirred until the different substances are thoroughly incorporated. Let the compound cool, and then lay it on a stone covered with powdered whitening, and heat it well until it becomes of a tough and firm consistence. It may then be put by for use, covered with wet cloths to keep it fresh. When wanted for use it must be cut into pieces adapted to the size of the mould, into which it is forced by a screw press. The ornament, or cornice, is fixed to the frame or wall with glue, or with white lead.

2203. Roman Cement. Calcine 3 parts of any ordinary clay, and mix it with 2 parts lime; grind it to powder, and calcine again. This makes a beautiful cement, improperly called Roman, since the preparation was entirely unknown to the Romans.

2204. New Plastic Material. A beautiful plastic substance can be prepared by mixing collodion with phosphate of lime. The phosphate should be pure, or the color of the compound will be unsatisfactory. On setting, the mass is found to be hard and susceptible of a very fine polish. The material can be used extensively, applied in modes that will suggest themselves to any intelligent artist, to high class decoration.

2205. Concrete. A compact mass, composed of pebbles, lime, and sand, employed in the foundations of buildings. The best proportions are 60 parts of coarse pebbles, 25 of rough sand, and 15 of lime; others recommend 80 parts pebbles, 40 parts river sand, and only 10 parts lime. The pebbles should not exceed about ½ pound each in weight. Abbé Moigno, in his valuable scientific journal, "Les Mondes," relates his personal experience with a concrete formed of fine wrought and cast iron filings and Portland cement. The Abbé states that a cement made thus is hard enough to resist any attempts to fracture it. As he states that the iron filings are to replace the sand usually put into the mixture, we presume that the relative quantities are to be similar.

2206. Concrete Floors and Walks. Compost for barn and kitchen floors:—After the ground on which the floor is intended to be made is leveled, let it be covered to the thickness of 3 or 4 inches with stones, broken small, and well rammed down; upon which let there be run, about 1½ inches above the stones, 1 part by measure calcined ferruginous marl, and 2 parts coarse sand and fine gravel, mixed to a thin consistence with water. Before this coating has become thoroughly set, lay upon it a coat of calcined marl, mixed with an equal part of fine sand, 1 to 1½ inches thick, leveled to an even surface. The addition of blood will render this compost harder. The calcined marl mentioned above is the Portland cement of commerce. (*See No.* 2195.)

2207. Concrete Gravel Walk. Dig away the earth to the depth of about 5 inches, then lay a bottom of pebbles, ramming them well down with a paving rammer. Sweep them off as clean as possible with a broom, and cover the surface thinly with hot coal tar. Now put on a coat of smaller gravel (the first bed of pebbles should be as large as goose eggs), previously dipped in hot coal tar, drained, and rolled in coal ashes, with an intermixture of fine gravel, and roll it down as thoroughly as possible. Let the roller run slowly, and let a boy follow it with a hoe to scrape off all adhering gravel. Next put on a coat of fine gravel or sand, and coal tar, with some coal ashes, to complete the surface, and roll again as thoroughly as possible; the more rolling the better. It will take some weeks to harden, but makes a splendid hard surface which sheds water like a roof. Do not use too much tar. It is only necessary to use enough to make the ingredients cohere under pressure, and a little is better than too much. Such a surface will last in a farmyard a great while.

2208. Cheap Concrete Flooring. Mix 3 bushels coal ashes from a blacksmith's shop with 2 bushels gas lime, and then add sufficient gas tar to make a stiff mortar. If the ammoniacal liquor has been separated from the tar, its place must be supplied by adding water till the tar is thin enough for use. For stables and cattle sheds, the mortar can be laid down with a spade, and fine sharp sand or gravel sifted over it; then roll well, and you will have a good concrete floor. It will take a few days to get thoroughly hard, even in dry weather; but it will be a good piece of work, if carefully done. Autumn is the best time for laying this kind of pavement.

2209. Keene's Marble Cement. This is made of baked gypsum or plaster of Paris, steeped in a saturated solution of alum, and then recalcined and reduced to powder. For use, it is mixed with water, as ordinary plaster of Paris. This cement has been most extensively applied as a stucco; but the finer qualities (when colored by the simple process of infusing mineral colors in the water with which the cement powder is finally mixed for working), being susceptible of a high degree of polish, produce beautiful imitations of mosaic, and other inlaid marbles, scagliola, &c. The cement is not adapted to hydraulic purposes, nor for exposure to the weather, but has been used as a stucco for internal decorations, and from its extreme hardness is very durable. A pleasing tint is given to this cement by adding a little solution of green copperas to the alum liquor.

2210. Parker's Cement. This valuable cement is made of the nodules of indurated and slightly ferruginous marl, called by mineralogists septaria, and also of some other species of argillaceous limestone. These are burned in conical kilns, with pit coal, in a similar way to other limestone, care being taken to avoid the use of too much heat, as, if the pieces undergo the slightest degree of fusion, even on the surface, they will be unfit to form the cement. After being properly roasted, the calx is reduced to a very fine powder by grinding, and immediately packed in barrels, to keep it from the air and moisture. It is tempered with water to a proper consistence, and applied at once, as it soon hardens, and will not bear being again softened down with water. For foundations and cornices exposed to the weather, it is usually mixed with an equal quantity of clean angular sand; for use as a common mortar, with about twice as much sand; for coating walls exposed to cold and wet, the common proportions are 3 of sand to 2 of cement, and for walls exposed to extreme dryness or heat, about 2½ or 3 of sand to 1 of cement; for facing cistern work, water frontages, &c., nothing but cement and water should be employed. This cement, under the name of compo, or Roman cement, is much employed for facing houses, water-cisterns, setting the foundations of large edifices, &c. It is perhaps the best of all cements for stucco.

2211. Pollack's Cement for Iron and Stone. This cement takes some little time to dry, but turns almost as hard as stone, and is fire and water-proof. For mending cracks in stone or cast-iron ware, where iron filings cannot be had, it is invaluable. Take litharge and red lead, equal parts, mix thoroughly and make into a paste with concentrated glycerine to the consistency of soft putty; fill the crack and smear a thin layer on both sides of the casting so as to completely cover the fracture. This layer can be rubbed off if necessary when nearly dry by an old knife or chisel. M. Pollack has used it to fasten the different portions of a fly-wheel with great success; while, when placed between stones, and once hardened, it is easier to break the stone than the joint.

2212. Cement from Furnace Slag. Furnace slag can be made to furnish an excellent cement by selecting such portions of it as are readily dissolved in dilute hydrochloric acid. On subjecting it to the action of the acid, silica is thrown down, which is afterward to be washed, dried, and pulverized. One part of this is next to be mixed with 9 parts powdered slag and the necessary quantity of slacked lime. This matter soon hardens, and rivals the best cement in its durability.

2213. Zeiodite. This substance is made by mixing 20 to 30 parts roll sulphur with 24 parts powdered glue or pumice, which forms a mass as hard as stone that resists the action of water and the strongest acids. Prof. R. Boettger recommends it, therefore, for making water-tight and air-tight cells for galvanic batteries.

2214. Cement for Closing Cracks in Stoves, etc. A useful cement for closing up cracks in stove plates, stove doors, etc., is prepared by mixing finely-pulverized iron, such as can be procured at the druggists, with liquid water-glass, to a thick paste, and then coating the cracks with it. The hotter the fire then becomes, the more does the cement melt and combine with its metallic ingredients, and the more completely will the crack become closed.

2215. Cement for Fastening Iron to Stone. A cement for fastening iron to stone, which becomes nearly as hard as the stone itself, consists of 6 parts Portland cement, 1 part powdered lime, not slacked, 2 parts sand, and 1 part slacked lime, mixed with water to the proper consistency, the stone and iron both being previously dampened. In 48 hours it will have set firmly.

2216. Strong Cement for Iron. To 4 or 5 parts clay, thoroughly dried and pulverized, add 2 parts iron filings free from oxide, 1 part peroxide of manganese, ½ part of sea salt, and ½ part borax. Mingle thoroughly, and render as fine as possible; then reduce to a thick paste with the necessary quantity of water, mixing thoroughly. It must be used immediately. After application, it should be exposed to warmth, gradually increasing almost to white heat. This cement is very hard, and presents complete resistance alike to a red heat and boiling water.

2217. Cement for Iron. An excellent cement is made by mixing equal parts of sifted peroxide of manganese and well-pulverized zinc white, adding a sufficient quantity of commercial soluble glass to form a thin paste. This mixture, when used immediately, forms a cement quite equal in hardness and resistance to that given in the last receipt.

2218. Cement for Uniting Stone, Derbyshire Spar, etc. Melt together 4 ounces resin, ½ ounce wax, and about an ounce finely-sifted plaster of Paris. The articles to be joined should be well cleaned, then made hot enough to melt the cement, and the pieces pressed together very closely, so as to leave as little as possible of the composition between the joints. This is a general rule with all cements, as the thinner the stratum of cement interposed the firmer it will hold.

2219. Cheap Artificial Building Stone. A large number of houses have been constructed in Paris, for workmen, of the following materials: 100 parts plaster of Paris, 10 parts hydraulic lime, 5 parts liquid glue, and 500 parts cold water, are intimately mixed and poured into moulds of any desired size and shape; and in half an hour the form can be removed. The stones are then exposed in the open air for 2 weeks, until they are thoroughly dry. Artificial stone thus prepared, has the ring and hardness of the native rock; and, where the materials are abundant, is said to be 25 per cent. cheaper than quarried stone.

2220. Simple and Useful Cement. Alum and plaster of Paris, well mixed in water and used in the liquid state, form a hard composition and also a useful cement.

2221. Cement for Fastening Instruments in Handles. A material for fastening knives or forks into their handles, when they have become loosened by use, is a much-needed article. The best cement for this purpose consists of 1 pound resin and 8 ounces sulphur, which are to be melted together and either kept in bars or reduced to powder. 1 part of the powder is to be mixed with ½ a part of iron filings, fine sand, or brick-dust, and the cavity of the handle is then to be filled with this mixture. The stem of the knife or fork is then to be heated and inserted into the cavity; and when cold it will be found firmly fixed in its place.

2222. Cement for Fastening Iron to Stone. Glycerine and litharge stirred to a paste, hardens rapidly, and makes a suitable cement for iron upon iron, for two stone surfaces, and especially for fastening iron to stone. The cement is insoluble, and is not attacked by strong acids.

2223. Vegetable Cement. A good vegetable cement may be prepared by mixing gum-arabic with *nitrate of lime*. The latter is prepared by dissolving an excess of marble in nitric acid, and filtering. The filtered solution will contain 33.3 per cent. nitrate of lime, which may be dried by evaporation. For the cement, take 2 parts by weight of the nitrate of lime, 20 parts pulverized gum-arabic, and 25 parts water. The mixture can be further diluted to adapt it to the uses to which it is to be applied. In the manufacture of artificial stone, a cement of a similar character has been found to serve a good purpose. Something of the kind is used in the Frear stone, but in the Béton-Coignet no additional binding material is found necessary.

2224. Cement for Leaky House Roofs. Take 4 pounds resin, 1 pint linseed oil, 2 ounces red lead, and stir in pulverized sand until the proper consistency is secured, and apply it warm. This cement becomes hard and yet possesses considerable elasticity, and is durable and waterproof.

2225. Engineer's Cement. Mix ground white lead with as much powdered red lead as will make it of the consistence of putty. This cement is employed by engineers and others to make metallic joints. A washer of hemp, yarn, or canvas, smeared with the cement, is placed in the joint, which is then screwed up tight. It dries as hard as stone. This cement answers well for joining broken stones, however large. Cisterns built of square stones, put together, while dry, with this cement, will never leak or require repair. It is only necessary to use it for an inch or two next the water; the rest of the joint may be filled with good mortar. It is better, however, to use it for the whole joint. (*See No.* 2169.)

2226. Plumbers' Cement. Melt 1 pound black resin, then stir in 1 to 2 pounds brick-dust. Sometimes a little tallow is added.

2227. Red Cement. The red cement used for uniting glass to metals is made by melting 5 parts black resin with 1 part yellow wax, and then stirring in gradually 1 part red ochre or Venetian red, in fine powder, and previously well dried. This cement requires to be melted before use, and it adheres better if the objects to which it is applied are warmed.

2228. Turners' Cement. Melt together bees' wax, 1 ounce; resin, ½ ounce; and pitch, ½ ounce; stir in the mixture some very fine brick-dust to give it a body. If too soft, add more resin; if too hard, more wax. When nearly cold, make it up into cakes or rolls for use. Used for fastening wood on a turner's chuck.

2229. Temporary Cement for Opticians, Jewelers, &c. A temporary cement to fix optical glasses, stones, jewelry, &c., on stocks or handles for the purpose of painting, repairing, or ornamenting, is made by melting together at a good heat, 2 ounces resin, 1 drachm wax, and 2 ounces whitening; with this applied to the article when heated, a secure hold may be obtained, unfixed at pleasure by heat.

2230. Cement for Fixing Metal to Leather. Wash the metal in hot gelatine, steep the leather in hot gall-nut infusion, and unite while hot.

2231. Cement for Fixing Metal to Marble, Stone, or Wood. Mix together 4 parts carpenters' glue and 1 part Venice turpentine.

2232. Cement for Coating Acid Troughs. Melt together 1 part pitch, 1 part resin, and 1 part plaster of Paris (perfectly dry.)

2233. To Cement Cloth to Polished Metal. Cloth can be cemented to polished iron shafts, by first giving them a coat of best white lead paint; this being dried hard, coat with best Russian glue, dissolved in water containing a little vinegar or acetic acid.

2234. Cement for Gas Retorts. A new cement, especially adapted to the retorts of gas-works, is very warmly recommended in a German gas-light journal. It consists of finely-powdered barytes and a soluble water-glass; or the barytes and a solution of borax. The joints are to be coated several times with this cement, by means of a brush. The addition of two-thirds of a part of clay improves the cement, and the retorts will then stand a red heat very well. Instead of the water-glass, a solution of borax may be used, or even finely powdered white glass.

2235. Use of Silicate of Potassa in Strengthening Fossil Skeletons. A very judicious application of the silicate of potassa (liquid glass) has been lately made at the Museum of Natural History of Paris, in repairing a great many fossil skeletons which had been disjointed and broken by the shells bursting in this Palace of Science. The solutions have been first used diluted to about 30° Baumé, and afterwards of a higher degree of concentration. The adherence of the broken or separated pieces is brought together by applying with a brush some of the solution of the silicate of potassa on the parts to be joined, then they are left to dry, and the joint is hardly visible; and the joined part is far stronger than the remainder of the bone. Very delicate and porous anatomical pieces, as skeletons of birds, insects, etc., can be dipped repeatedly in more diluted solutions, and thus be rendered very hard and tenacious.

2236. Transparent Cement for Lenses, &c. It is frequently found necessary to cement together two surfaces of transparent glass, without destroying or injuring their transparency; this is especially the case in compound lenses. The best cement for effecting the union is Canada balsam, which, if too thick, should be thinned with a little turpentine, benzole, or ether. It is of importance that no air bubbles be present. In order to cement together the two parts of an achromatic lens (this consists of a double convex lens fitting exactly into the concavity of a plano-concave lens), having thoroughly cleaned the surfaces to be brought in contact, lay the glass, previously made warm, on a table suitably covered to prevent the under surface from being scratched. By means of a peg of wood or otherwise, convey a drop of the balsam to the centre of the lens, and then gently lower down upon it the lens to be cemented to it, also previously made slightly warm. Now apply a slight pressure, and the dark disc in the centre, indicative of optical contact, will rapidly increase in size, until at last the balsam reaches the margin and begins to ooze out at the edges, if the balsam be present in excess, as it should be. By means of a piece of soft string passed crosswise over the lenses, tie the two together, and place them in a stove, an oven, or before a fire, for a short time, until the balsam at the edges shall have become hard and dry. Let the string then be removed and the lens freed from all external traces of balsam by means of benzole or ether. The above directions, modified to suit circumstances, apply to the cementation of transparencies or opal pictures; also to the varnishing of magic lantern slides, and the protection of any transparent surfaces from the air.

2237. Cement for Chemical Glasses. Mix equal parts of wheat flour, finely-powdered Venice glass, pulverized chalk, and a small quantity of brick-dust, finely ground; these ingredients, with a little scraped lint, are to be mixed and ground up with the white of eggs; it must then be spread upon pieces of fine linen cloth, and applied to the crack of the glasses, and allowed to get thoroughly dry before the glasses are put to the fire.

2238. Hermetical Sealing for Bottles. Gelatine mixed with glycerine yields a compound, liquid when hot, but becoming solid by cooling, at the same time retaining much elasticity. Bottles may be hermetically sealed by dipping their necks into the liquid mixture, and repeating the operation until the cap attains any thickness required.

2239. Cement to Seal Bottles Containing Volatile Liquids. Chemists and others know well the difficulty of keeping volatile liquids. Bottles of ether, for example, are shipped for India, and when they arrive are found to be more than half empty. The remedy with exporters is a luting of melted sulphur, which is difficult to apply and hard to remove. A new cement, easily prepared and applied, and which is said to prevent the escape of the most volatile liquids, is composed of very finely ground litharge and concentrated glycerine, and is merely painted around the cork or stopper. It quickly dries and becomes extremely hard, but can be easily scraped off with a knife when it is necessary to open the bottle.

2240. Cement for Sealing Corks in Bottles. Take an equal quantity of resin and bees' wax, melt them together, then put in an almost equal bulk of finely-powdered red chalk, add a small quantity of neatsfoot oil, let the whole boil 1 minute, then take it from the fire and stir it well; if too thick, add a little more oil.

2241. Cement for Sealing the Corks in Bottles. Melt together ¼ pound sealing-wax, the same quantity of resin, and 2 ounces bees' wax. When it froths stir it with a tallow candle. As soon as it melts dip the mouths of the corked bottles in it.

2242. Painters' Putty. Putty is made of common whitening, pounded very fine, and mixed with linseed oil till it becomes about the thickness of dough.

2243. Quick Hardening Putty. A putty of starch and chloride of zinc hardens quickly, and lasts for months, as a stopper of holes in metals.

2244. Cement to Stop Flaws or Cracks in Wood of any Color. Put any quantity of fine sawdust, of the same wood the work is made with, into an earthen pan, and pour boiling water on it, stir it well, and let it remain for a week or ten days, occasionally stirring it; then boil it for some time, and it will be of the consistence of pulp or paste; put it into a coarse cloth, and squeeze all the moisture from it. Keep for use, and, when wanted, mix a sufficient quantity of thin glue to make it into a paste; rub it well into the cracks, or fill up the holes in the work with it. When quite hard and dry, clean the work off, and, if carefully done, the imperfection will be scarcely discernible.

2245. Cement for Cloth, Leather, or Belting. Take ale, 1 pint; best Russia isinglass, 2 ounces; put them into a common glue kettle and boil until the isinglass is dissolved; then add 4 ounces best glue, and dissolve it with the other; then slowly add 1½ ounces boiled linseed oil, stirring all the time while adding and until well mixed. When cold it will resemble India rubber. To use this, dissolve what is needed in a suitable quantity of ale to the consistence of thick glue. It is applicable for leather, for harness, bands for machinery, cloth belts for cracker machines for bakers, &c., &c. If for leather, shave off as if for sewing, apply the cement with a brush while hot, laying a weight to keep each joint firmly for 6 to 10 hours, or over night.

2246. Cement for Leather Belting. Take of common glue and American isinglass, equal parts; place them in a glue-pot and add water sufficient to just cover the whole. Let it soak 10 hours, then bring the whole to a boiling heat, and add pure tannin until the whole becomes ropey or appears like the white of eggs. Apply it warm. Buff the grain off the leather where it is to be cemented; rub the joint surfaces solidly together, let it dry a few hours, and it is ready for use; and, if properly put together, it will not need riveting, as the cement is nearly of the same nature as the leather itself. We know of no cement better either for emery wheels or emery belts than the best glue. In an experience of fifteen years we never found anything superior.

2247. Gutta-Percha Cement. This highly recommended cement is made by melting together, in an iron pan, 2 parts common pitch and 1 part gutta-percha, stirring them well together until thoroughly incorporated, and then pouring the liquid into cold water. When cold it is black, solid, and elastic; but it softens with heat, and at 100° Fahr. is a thin fluid. It may be used as a soft paste, or in the liquid state, and answers an excellent purpose in cementing metal, glass, porcelain, ivory, &c. It may be used instead of putty for glazing windows.

2248. To Dissolve India Rubber for Cement, &c. India rubber dissolves readily in rectified sulphuric ether, which has been washed with water to remove alcohol and acidity; also in chloroform. These make odorless solutions, but are too expensive for general use. The gum dissolves easily in bisulphuret of carbon; or a mixture of 94 parts bisulphuret of carbon and 6 parts absolute alcohol; also in caoutchoucine. (*See No.* 2249.) These dissolve the gum rapidly in the cold, and leave it unaltered on evaporation; they have a disagreeable odor, but they leave the India rubber in better condition than most other solvents. Oil of turpentine, rendered pyrogenous by absorbing it with bricks of porous ware, and distilling it without water, and treating the product in the same way, is also used for this purpose. It is stated that the solution on evaporation does not leave the caoutchouc in a sticky state. Another method is to agitate oil of turpentine repeatedly with a mixture of equal weights of sulphuric acid and water; and afterwards expose it to the sun for some time. Benzole, rectified mineral or coal tar naphtha, and oil of turpentine reduce the gum slowly by long digestion and trituration, with heat, forming a glutinous jelly which dries slowly, and leaves the gum, when dry, very much reduced in hardness and elasticity. The fats and fixed oils combine readily with India rubber by boiling, forming a permanently glutinous paste. (*See No.* 2947.) India rubber is rendered more readily soluble by first digesting it with a solution of carbonate of soda, or water of ammonia.

2249. Caoutchoucine. Pure India rubber, cut into small lumps, is thrown into a cast-iron still, connected with a well-cooled worm tub, and heat is applied until the thermometer ranges about 600° Fahr., when nothing is left in the still but dirt and charcoal. The dark colored fetid oil which has distilled over is next rectified with one third its weight of water, once or oftener, until it is colorless; it is then highly volatile and of .680 specific gravity. The product is then shaken up with nitro-muriatic acid, or chlorine, in the proportion of ¼ pint of acid to each gallon of the liquid. This is the lightest fluid known, and yet its vapor is the heaviest of gases. Mixed with alcohol, it dissolves all the resins, especially copal and India rubber, at the common temperature of the air; and it speedily evaporates, leaving them in a solid state. It mixes with the oils in all proportions; and has been used for making varnishes, and for liquefying oil paints, instead of turpentine. It is very volatile, and must be kept in close vessels.

2250. Cement for Uniting Sheet Gutta-Percha to Silk, &c. Gutta-percha, 40 pounds; caoutchouc, 3 pounds; shellac, 3 pounds; Canada balsam, or Venice turpentine, 14 pounds; liquid storax, 35 pounds; gum mastic, 4 pounds; oxide of lead, 1 pound. Mix as directed in the next receipt.

2251. Cement for Uniting Sheet Gutta-Percha to Leather. For uniting sheet gutta-percha to leather, as soles of shoes, etc. Gutta-percha, 50 pounds; Venice turpentine, 40 pounds; shellac, 4 pounds; caoutchouc, 1 pound; liquid storax, 5 pounds. In making the cement, the Venice turpentine should be first heated; then the gutta-percha and the shellac should be added; the order in which the other materials are added is not important. Care should be taken to incorporate them thoroughly, and the heat should be regulated, so as not to burn the mixture.

2252. Transparent Cement. Dissolve 75 parts India rubber in 60 parts of chloroform, and add to the solution 15 parts of gum mastich.

2253. How to Fasten Rubber to Wood and Metal. As rubber plates and rings are now-a-days almost exclusively used for making connections between steam and other pipes and apparatus, much annoyance is often experienced by the impossibility or imperfectness of an air-tight connection. This is obviated entirely by employing a cement which fastens equally well to the rubber and to the metal or wood. Such cement is prepared by a solution of shellac in ammonia. This is best made by soaking pulverized gum-shellac in ten times its weight of strong ammonia, when a slimy mass is obtained, which, in three to four weeks, will become liquid without the use of hot water. This softens the rubber, and becomes, after volatilization of the ammonia, hard and impermeable to gases and fluids.

2254. Marine Cement for Uniting Leather to Gutta-Percha. This will unite leather to gutta-percha, and is impervious to damp. It is made by dissolving by the aid of heat, 1 part India rubber in naphtha, and, when melted, adding 2 parts shellac, and melting until mixed. Pour it while hot on metal plates to cool. When required for use, melt, and apply with a brush. This cement does not adhere very well to *vulcanized* rubber, and the joint is always weak.

2255. Cement to Unite India Rubber. Take 16 parts gutta-percha, 4 parts India rubber, 2 parts common caulkers' pitch, 1 part linseed oil. The ingredients are melted together, and used hot. It will unite leather or rubber that has not been vulcanized.

2256. Gutta-Percha Cement for Fastening Leather. Dissolve a quantity of gutta-percha in chloroform in quantity to make a fluid of honey-like consistence. When spread it will dry in a few moments. Heat the surfaces at a fire or gas flame until softened, and apply them together. Small patches of leather can be thus cemented on boots, etc., so as almost to defy detection, and some shoemakers employ it with great success for this purpose. It is waterproof, and will answer almost anywhere unless exposed to heat, which softens it.

2257. Caoutchouc Cement is made as follows:—Gutta-percha, 3 parts; virgin India rubber (caoutchouc), 1 part (both cut small); pyrogenous oil of turpentine, or bisulphuret of carbon, 8 parts; mix in a close vessel, and dissolve by the heat of hot water. This cement should be gently heated before being used.

2258. Cement to Mend India Rubber Shoes. A solution of caoutchouc, or virgin India rubber, for repairing India rubber shoes, is prepared in the following manner: Cut 2 pounds caoutchouc into thin, small slices; put them in a vessel of tinned sheet-iron and pour over 12 to 14 pounds of sulphide of carbon. For the promotion of solution, place the vessel in another containing water previously heated up to about 86° Fahr. The solution will take place promptly, but the fluid will thicken very soon, and thus render the application difficult, if not impossible. In order to prevent this thickening, a solution of caoutchouc and resin in spirits of turpentine must be added to the solution of caoutchouc in sulphide of carbon, and in such quantity that the mixture obtains the consistency of a thin paste. The solution of caoutchouc and resin in spirit of turpentine should be prepared as follows: Cut 1 pound of caoutchouc into thin, small slices; heat in a suitable vessel over a moderate coal fire, until the caoutchouc becomes fluid; then add ½ pound powdered resin, and melt both materials at a moderate heat. When these materials are perfectly fluid, then gradually add 3 or 4 pounds spirit of turpentine in small portions, and stir well. By the addition of the last solution, the rapid thickening and hardening of the compound will be prevented, and a mixture obtained fully answering the purpose of glueing together rubber surfaces, etc.

2259. To Fasten Chamois and Other Leather to Iron and Steel. Dr. Carl W. Heinischen, of Dresden, gives the following receipt for the above purpose: Spread over the metal a thin, hot solution of good glue; soak the leather with a warm solution of gall-nuts before placing on the metal, and leave to dry under an even pressure. If fastened in this manner it is impossible to separate the leather from the metal without tearing it.

2260. Cement for Petroleum Lamps. A cement particularly adapted for attaching the brass work to petroleum lamps, is made by Puscher, by boiling 3 parts resin with 1 of caustic soda and 5 of water. The composition is then mixed with half its weight of plaster of Paris, and sets firmly in half to three-quarters of an hour. It is said to be of great adhesive power, not permeable to petroleum, a low conductor of heat, and but superficially attacked by hot water. Zinc white, white lead, or precipitated chalk may be substituted for plaster, but hardens more slowly.

2261. Cement for Attaching Metal Letters to Plate Glass. Copal varnish, 16 parts; drying oil, 6 parts; turpentine, and oil of turpentine, of each 3 parts; liquefied glue (made with the least possible quantity of water), 5 parts. Melt together in a water-bath, and add fresh slacked lime (perfectly dry and in very fine powder), 10 parts.

2262. Cement for Metal and Glass. Mix 2 ounces of a thick solution of glue with 1 ounce linseed oil varnish, or ½ ounce Venice turpentine; boil them together, stirring them until they mix as thoroughbly as possible. The pieces cemented should be tied together for 2 or 3 days. This cement will firmly attach any metallic substance to glass or porcelain. (*See last receipt.*)

Lute.

A composition employed to secure the joints of chemical vessels, or as a covering to protect them from the violence of the fire. For the joints of vessels, as stills, &c., not exposed to a heat much higher than 212° Fahr., linseed meal, either alone or mixed with an equal weight of whiting, and made into a stiff paste with water, may be employed. Ground almond cake, from which the oil has been pressed, may also be used for the same purpose. For the joints of small vessels, as tubes, &c., especially of glass or earthenware, small rings of India rubber slipped over and tied above and below the joint, are very convenient substitutes for lutes, and have the advantage of lasting a long time, and bearing uninjured the heat at which oil of vitriol boils.

2264. Lute for Stills. A very useful lute is formed by beating the white of an egg thoroughly with an equal quantity of water, and mixing it with some slacked lime in the state of fine powder, so as to form a thin paste. This must be spread immediately on strips of muslin, and applied to the cracks or joints intended to be luted. It soon hardens, adheres strongly, and will bear a heat approaching to redness without injury. A leak in this lute is readily stopped by the application of a fresh portion. Solution of glue, or any liquid albuminous matter, may be used in place of the white of eggs.

2265. Lemery's Lute for Stills or Retorts. Lemery used the following lute for stopping retorts, etc.: Fine flour and fine lime, of each 1 ounce; potter's earth, ¼ ounce; make a moist paste of these with white of egg, well beaten up with a little water; this will be found to stop exceedingly close.

2266. Boyle's Lute for Retorts, &c. Boyle recommends, on experience, the following for the same purpose: Some good fine quicklime and scrapings of cheese, pounded in a mortar, with as much water as will bring the mixture to soft paste; then spread on a piece of linen rag, and apply it as occasion requires.

2267. Useful Lute. A useful lute is made by spreading a solution of glue on strips of cloth, and coating them, after they are applied, with drying oil.

2268. Lute for Joining Crucibles. For joining crucibles to be exposed to a strong heat, a mixture of fine clay and ground bricks, mixed up with water, or preferably with a solution of borax, answers well for most purposes.

2269. Fire Lute. As a coating for vessels, to preserve them from injury from exposure to the fire, nothing is better than a mixture of ordinary pipe-clay and horse dung, made into a paste with water. This composition is used by the pipe-makers, and will stand unharmed the extreme heat of their kiln for 24 hours. It is applied by spreading it on paper.

2270. Lute to Protect Glass Vessels. The following composition will enable glass vessels to sustain an incredible degree of heat: Take fragments of porcelain, pulverize, and sift them well, and add an equal quantity of fine clay, previously softened with as much of a saturated solution of muriate of soda as is requisite to give the whole a proper consistence. Apply a thin and uniform coat of this composition to the glass vessels, and allow it to dry slowly before they are put into the fire.

Flour Paste.

The best paste for general purposes is simply wheat flour beaten into cold water to perfect smoothness, and the whole just brought to a boil, while being constantly stirred to prevent burning. The addition of a few drops of creosote, or a few grains of corrosive sublimate, or a little carbolic acid, or bisulphite of lime (especially the first and second), will prevent insects from attacking it, and preserve it (in covered vessels) for years. Should it get too hard it may be softened with water.

2272. Paper Hangers' Paste. Beat up 4 pounds of good white wheat flour in cold water—enough to form a stiff batter (sifting the flour first); beat it well, to take out all lumps; then add enough cold water to make it the consistence of pudding batter; add about 2 ounces of well pounded alum. Be sure and have plenty of boiling water ready; take it quite boiling from the fire, and pour gently and quickly over the batter, stirring rapidly at the same time; and when it is observed to swell and lose the white color of the flour, it is cooked and ready. This will make about ¾ of a pail of solid paste; do not use it while hot; allow it to cool and it will go further; about a pint of cold water may be put over the top of it, to prevent it skinning; before using, thin this with cold water to spread easily and quickly under the brush. This paste will keep a long while without fermenting, when it is useless; mould on the top does not hurt it; remove it, the remainder is good. (*See No.* 2273.)

2273. Strongly Adhering Paste. Where great adhesiveness is required, such as papering over varnished paper or painted walls, it will be necessary to add ¼ an ounce of finely powdered resin to each ¼ gallon of the batter in the last receipt. As the resin does not dissolve so readily, set the pan containing the ingredients over a moderate fire, constantly stirring until it boils and thickens, and a short time after put out to cool. Reduce the paste with thin gum-arabic water. In hanging "flock" papers with crimson in them, omit the alum, as it will injure the color.

2274. To Make a Fine Paste. A solution of 2½ ounces gum-arabic in 2 quarts warm water, is thickened to a paste with wheat flour; to this is added a solution of alum and sugar of lead, 1¼ ounces each in water; the mixture is heated and stirred about to boil, and is then cooled. It may be thinned, if necessary, with a gum solution.

2275. To Make Paste for Laying Cloth or Leather on Table Tops. To 1 pint best wheaten flour add resin, very finely powdered, about 2 large spoonfuls; of alum, 1 spoonful, in powder; mix them all well together, put them into a pan, and add by degrees soft or rain water, carefully stirring it till it is of the consistence of thinnish cream; put it into a saucepan over a clear fire, keeping it constantly stirred, that it may not get lumpy. When it is of a stiff consistence, so that the spoon will stand upright in it, it is done enough. Be careful to stir it well from the bottom, for it will burn if not well attended to. Empty it out into a pan and cover it over till cold, to prevent a skin forming on the top, which would make it lumpy. This paste is very superior for the purpose, and adhesive.

2276. To Paste Leather or Cloth on Table Tops. To use paste in the last receipt, for cloth or baize, spread the paste evenly and smoothly on the top of the table, and lay your cloth on it, pressing and smoothing it with a flat piece of wood; let it remain till dry; then trim the edges close to the cross-banding. If you cut it close at first, it will, in drying, shrink and look bad where it meets the banding all around. If used for leather, the leather must be first previously dampened, and then the paste spread over it; next lay it on the table, and rub it smooth and level with a linen cloth, and cut the edges close to the banding with a short knife. Some lay their table-covers with glue instead of paste, and for cloth perhaps it is the best method; but for leather it is not proper, as glue is apt to run through. In using it for cloth, great care must be taken that the glue is not too thin, and that the cloth be well rubbed down with a thick piece of wood made hot at the fire, for the glue soon chills. You may, by this method, cut off the edges close to the border at once.

Glue. The hotter the glue, the more force it will exert in keeping the two parts glued together; therefore, in all large and long joints the glue should be applied immediately after boiling. Glue loses much of its strength by frequent re-melting; that glue, therefore, which is newly made, is much preferable to that which has been re-boiled. In melting ordinary glue in the double vessel containing water, it is an excellent method to add salt to the water in the outer vessel. It will not boil then, until heated considerably above the ordinary boiling point; the consequence is, the heat is retained, instead of passing off by evaporation, and when the water boils, the glue will be found to be thoroughly and evenly melted.

2278. To Prevent Glue from Cracking. Glue is often found to crack in very dry localities, particularly when the objects glued together are not in close contact, but have a thin layer of glue between them; in which case they sometimes fall apart. Very thin layers of glue are not only exceedingly hard, but also more or less brittle when extremely dry; and, therefore, to prevent this dry and consequent brittle condition, the addition of a very small quantity of glycerine will accomplish the desired end. The quantity of glycerine must be modified according to circumstances.

2279. To Make a Very Strong Glue. An ounce of the best isinglass may be dissolved, by the application of a moderate heat, in a pint of water. Take this solution and strain it through a piece of cloth, and add to it a proportionate quantity of the best glue, which has been previously soaked in water for about 24 hours, and a gill of vinegar. After the whole of the materials have been brought into a solution, let it once boil up, and strain off the impurities. This glue is well adapted for any work which requires particular strength, and where the joints themselves do not contribute towards the combination of the work; or in small fillets and mouldings, and carved patterns that are to be held on the surface by the glue.

2280. A Strong Glue that will Resist Moisture. Dissolve gum-sandarac and mastich, of each ¼ ounce, in ¼ pint spirits of wine, to which add ¼ ounce clear turpentine; now take strong glue, or that in which isinglass has been dissolved; then, putting the gums into a double glue-pot, add by degrees the glue, constantly stirring it over the fire till the whole is well incorporated; strain it through a cloth, and it is ready for use. It may now be returned to the glue-pot, and ½ ounce very finely-powdered glass added; use it quite hot.

2281. To Make Tungstic Glue. Tungstic glue is prepared by mixing a thick solution of glue with tungstate of soda, and hydrochloric acid, by means of which a compound of tungstic acid and glue is precipitated, which, at a temperature of 86° to 104° Fahr., is sufficiently elastic to admit of being drawn out into very thin sheets. On cooling, this mass becomes solid and brittle, and on being heated is again soft and plastic. This new compound, it is said, can be used for all the purposes to which hard rubber is adapted.

2282. To Keep Glue from Souring. If a little muriatic acid be put into glue when it is dissolved, ready for use, it will retain the glue in the same condition for a long time. It will neither dry up nor ferment. Liquid glue is made in this way, and sold in bottles. The use of a small portion of sugar of lead will also prevent fermentation.

2283. To Prepare Glue for Ready Use. To any quantity of glue use common whiskey instead of water. Put both together in a bottle, cork it tight, and set it for 3 or 4 days, when it will be fit for use without the application of heat. Glue thus prepared will keep for years, and is at all times fit for use, except in very cold weather, when it should be set in warm water before using. To obviate the difficulty of the stopper getting tight by the glue drying in the mouth of the vessel, use a tin vessel with the cover fitting tight on the outside, to prevent the escape of the spirit by evaporation. A strong solution of isinglass made in the same manner is an excellent cement for leather.

2284. Liquid Glue. The preparation of liquid glue is based upon the property of the concentrated acid of vinegar and diluted nitric acid to dissolve the gelatine without destroying its cohesive qualities. Dumoulin has given the following receipt:

2285. Dumoulin's Liquid and Unalterable Glue. Take a wide-mouthed bottle, and dissolve in it 8 ounces best glue in ½ pint water, by setting it in a vessel of water, and heating until dissolved. Then add slowly 2¼ ounces strong aqua fortis (nitric acid) 36° Baumé, stirring all the while. Effervescence takes place under generation of nitrous gas. When all the acid has been added, the liquid is allowed to cool. Keep it well corked, and it will be ready for use at any moment. This preparation does not gelatinize, nor undergo putrefaction or fermentation. It is applicable for many domestic uses, such as mending china, repairing cabinet work, &c.

2286. Russian Liquid Glue. This is prepared by softening 100 parts best Russian glue in 100 parts warm water, and then adding slowly from 5½ to 6 parts aqua fortis, and finally 6 parts powdered sulphate of lead. The latter is used in order to impart to it a white color.

2287. Pale Liquid Glue. Dissolve in a glass vessel 100 parts pale "steam glue" in double its weight of water, and add 12 parts aqua fortis as directed in Dumoulin's receipt. (*See No.* 2285.)

2288. Dark Liquid Glue. Put 100 parts dark "steam glue" and 140 parts water in a wide-mouthed glass bottle, and dissolve the glue in the water, then add slowly 16 parts aqua fortis, stirring all the while. When all the acid is added, the liquid is allowed to cool. Cork well. This liquid glue exhibits a greater cohesive force than that prepared after Dumoulin's receipt. (*See No.* 2285.) However, still better kinds of liquid glue or mucilage are obtained by dissolving gelatine or dextrine in acetic acid and alcohol.

2289. Good Liquid Glue. Fill a glass jar with broken-up glue of best quality, then fill it with acetic acid. Keep it in hot water for a few hours, until the glue is all melted, and you will have an excellent glue always ready.

2290. Glue which Stands Moisture Without Softening. Dissolve, in about 8 fluid ounces of strong methylated spirit, ½ an ounce each of sandarac and mastich; next, add ½ an ounce of turpentine. This solution is then added to a hot, thick solution of glue to which isinglass has been added, and is next filtered, while hot, through cloth or a good sieve. (*See No.* 2280.)

2291. Marine or Waterproof Glue. Take of gum shellac 3 parts, caoutchouc (India-rubber), 1 part, by weight. Dissolve the caoutchouc and shellac in separate vessels, in ether free from alcohol (*see No.* 2248), applying a gentle heat. When thoroughly dissolved, mix the two solutions, and keep in a bottle tightly stoppered. This glue resists the action of water, both hot and cold, and most of the acids and alkalies. Pieces of wood, leather or other substances, joined together by it, will part at any other point than at the joint thus made. If the glue be thinned by the admixture of ether, and applied as a varnish to leather, along the seams where it is sewed together, it renders the joint or seam water-tight, and almost impossible to separate.

2292. Isinglass Glue. Dissolve isinglass in water and strain through coarse linen, and then add a little spirits of wine. Evaporate it to such a consistency that when cold it will be dry and hard. This will hold stronger than common glue, and is much preferred.

2293. India-Rubber Glue for Photographers and Bookbinders. A most valuable glue for photographers, and extensively used by first-class bookbinders, is made from bottle India rubber. This must be dissolved in highly rectified spirits of turpentine; the highly rectified spirit extracts every particle of grease, which is of the greatest consequence.

2294. Braconnot's Glue of Caseine. Dissolve caseine in a strong solution of bicarbonate of soda.

2295. Wagner's Glue of Caseine. Dissolve caseine in a cold saturated solution of borax. Superior to gum, and may take the place of glue in many cases. May be used for the backs of adhesive tickets.

2296. To Glue a Joint. In general, nothing more is necessary to glue a joint, after the joint is made perfectly straight, than to glue both edges while the glue is quite hot, and rub them lengthwise until it has nearly set. When the wood is spongy, or sucks up the glue, another method must be adopted—one which strengthens the joint, while it does away with the necessity of using the glue too thick, which should always be avoided; for the less glue there is in contact with the joints, provided they touch, the better; and when the glue is thick, it chills quickly, and cannot be well rubbed out from between the joints. The method to which we refer is, to rub the joints on the edge with a piece of soft chalk, and, wiping it so as to take off any lumps, glue it in the usual manner; and it will be found, when the wood is porous, to hold much faster than if used without chalking.

2297. To Glue on Ivory Veneers. To glue on ivory veneers, take 2 parts pulverized gum-arabic and 1 part calomel, and add water sufficient to make a paste.

2298. Excellent Liquid Glue. Take of best white glue, 16 ounces; white lead, dry, 4 ounces; rain water, 2 pints; alcohol, 4 ounces. With constant stirring dissolve the glue and lead in the water by means of a water-bath. Add the alcohol and continue the heat for a few minutes. Lastly pour into bottles while it is still hot. This is said to be superior to "Spaulding's liquid glue."

2299. Glycerine Paste for Office Use. Glycerine paste for office use may be prepared by dissolving 1 ounce gum-arabic and 2 drachms of glycerine in 3 ounces boiling water.

2300. Government Postage Stamp Mucilage. The substance used for gumming stamps is made as follows. Gum dextrine, 2 parts; acetic acid, 1 part; water, 5 parts. Dissolve in a water-bath, and add alcohol, 1 part.

2301. Mucilage for Labels. Macerate 5 parts good glue in 18 to 20 parts water for a day, and to the liquid add 9 parts rock candy and 3 parts gum-arabic. The mixture can be brushed upon paper while lukewarm; it keeps well, does not stick together, and, when moistened, adheres firmly to bottles.

2302. Mucilage for Soda or Seltzer Water Bottles. For the labels of soda or seltzer water bottles it is well to prepare a paste of good rye flour and glue to which linseed oil varnish and turpentine have been added in the proportion of ½ an ounce of each to the pound. Labels prepared in the latter way do not fall off in damp cellars.

2303. Very Strong Liquid Glue. To make this, put 3 parts glue in 8 parts cold water, and let them stand for several hours to soften the glue; then add ½ part muriatic acid and ¾ part sulphate of zinc, and heat the mixture to 185° Fahr., for 10 or 12 hours. The mixture remains liquid after cooling, and is said to be very useful for sticking wood, crockery, and glass together.

2304. Good Mucilage. For household purposes this may be made by mixing 3 ounces gum-arabic, 3 ounces distilled vinegar, with 1 ounce white sugar. Instead of the distilled vinegar, 1 part acetic acid and 5 parts water may be substituted.

2305. To Prevent Mould in Mucilage. Solutions of gum-arabic are very liable to become mouldy; and while the introduction of creosote, corrosive sublimate, etc., frequently used to remedy this evil, is objectionable on account of the danger of poisoning, according to the "Industrie Blätter," sulphate of quinine is a complete protection against mould, a very small quantity of it being sufficient to prevent gum mucilage from spoiling. It is quite possible that writing ink might be protected, by the same application, from a like difficulty. The use of ammonia for the same purpose is also recommended.

2306. Elastic Glue which does not spoil is obtained as follows: Good common glue is dissolved in water, on the water-bath, and the water evaporated down to a mass of thick consistence, to which a quantity of glycerine, equal in weight with the glue, is added, after which the heating is continued until all the water has been driven off, when the mass is poured out into moulds, or on a marble slab. This mixture answers for stamps, printers' rolls, galvano-plastic copies, etc.

2307. Sweet Mouth Glue. Sweet glue, for ready use by moistening with the tongue, is made in the same way as elastic glue, substituting, however, the same quantity of powdered sugar for the glycerine.

2308. Portable Glue or Bank-Note Cement. Boil 1 pound best glue, strain it very clear; boil also 4 ounces isinglass; put it into a double glue-pot, with ½ pound fine brown sugar, and boil it pretty thick; then pour it into plates or moulds. When cold, you may cut and dry them for the pocket. This glue is very useful to draughtsmen, architects, &c., as it immediately dilutes in warm water, and fastens the paper without the process of damping; or, it may be used by softening it in the mouth, and applying it to the paper.

2309. To Make Mucilage that will Adhere to Glass or Polished Surfaces. We all know the difficulty of causing labels and similar objects to stick to glass or highly varnished articles exposed to the continued drying action of a very warm room. The gum or paste dries up and cracks, causing the label to fall off. One or two drops of glycerine in a small bottle of mucilage will entirely prevent this result. Too much glycerine must not be added, or the cement will fail to harden at all.

2310. Mucilage of Tragacanth. Triturate 1 drachm powdered gum tragacanth in a mortar with 6 drachms glycerine; add by degrees, with constant trituration, 10 fluid ounces water. This will produce a mucilage at once, without the objectionable air-bubbles incidental to agitation.

2311. Mucilage of Tragacanth. Macerate 1 ounce tragacanth in 1 pint boiling water for 24 hours. Then triturate until smooth and uniform, and press through linen. If pretty firm this paste keeps well without the addition of an antiseptic, although a little acetic acid or creosote will more effectually prevent fermentation.

Sealing-Wax.

All the following receipts for *fine* wax produce *superfine* by employing the best qualities of the ingredients; and *extra superfine* or *scented* by adding 1 per cent. of balsam of Peru or liquid storax to the ingredients when considerably cooled. The fancy kinds are commonly scented with a little essence of musk or ambergris, or any of the more fragrant essential oils. The addition of a little camphor, or spirit of wine, makes sealing-wax burn easier. Sealing-wax containing resin, or too much turpentine, runs into thin drops at the flame of the candle.

2313. Fine Red Sealing-Wax. Melt cautiously 4 ounces very pale shellac in a bright copper pan over a clear charcoal fire, at the lowest degree of heat that will be necessary to melt it; when melted, stir in 1¼ ounces Venice turpentine (previously warmed), followed by 3 ounces vermilion. The heat must be neither too much nor too little, but just sufficient to allow a most thorough mixing of the different ingredients. When this is accomplished, the fluid mass is discharged into metallic moulds and left to cool. For the purpose of melting the shellac more easily, some add to the same a little alcohol. Or: 3 pounds shellac, 1¼ pounds Venice turpentine, and 2 pounds finest cinnabar, mixed in the same manner as the preceding.

2314. To Produce a Polish on Sealing-Wax. After the above process the sticks of sealing-wax have no polish. To produce this they have to be heated again on the surface. For this purpose they are put in other moulds, made of polished steel, which are engraved with the desired ornaments. These moulds are heated only just sufficient to melt the sealing-wax on the surface, by which operation the sticks obtain a beautiful glossy appearance. The heating of the moulds to stamp the mark of the manufacturer can be readily performed with a spirit lamp.

2315. Common Red Sealing-Wax. Melt together 4 pounds resin and 2 pounds shellac; mix in, as in the last receipt, 1½ pounds each of Venice turpentine and red lead.

2316. Fine Black Sealing-Wax. Take 60 parts shellac, 30 parts finely-powdered ivory black, and 20 parts Venice turpentine; mixed as in No. 2313.

2317. Common Black Sealing-Wax. Mix together (*see No.* 2313) 6 pounds resin, 2 pounds each shellac and Venice turpentine, and sufficient lampblack to color.

2318. Gold Colored Sealing-Wax. This is made by stirring gold colored mica spangles into the melted resins just before they begin to cool. Or: By taking finely pulverized gold-leaf (*see No.* 25) or metal powder, and stirring them into the sealing-wax instead of the colors. A common kind is made as follows: 6 parts shellac, 2 white resin, 1 silver leaves.

2319. Marbled Sealing-Wax is made by mixing different kinds of sealing-wax together just as they begin to solidify.

2320. Yellow Sealing-Wax. Mix together 4 ounces pale shellac, 1¼ ounces resin, 2 ounces Venice turpentine, and ¾ ounce King's yellow (sulphuret of arsenic, or orpiment).

2321. Light Brown Sealing-Wax. Take 7½ ounces shellac and 4 ounces Venice turpentine; and color with 1 ounce brown ochre and ½ ounce cinnabar (red sulphuret of mercury or vermilion).

2322. Blue Sealing-Wax. Take 16 parts mastic, 4 turpentine, 8 mountain-blue, 3 burned selenite. The mountain-blue turns green by the heat of melting the mixture; therefore it is better to use fine indigo, or very fine Prussian blue; but in that case the shellac must be particularly light-colored.

2323. Dark Blue Sealing-Wax. Mix 7 ounces fine shellac, 3 ounces Venice turpentine, 1 ounce resin, and 1 ounce mineral blue.

2324. Green Sealing-Wax. Mix 4 ounces shellac, 2 ounces Venice turpentine, 1½ ounces resin, ½ ounce King's yellow (*see No.* 2320), and ¼ ounce mineral blue. Or: 24 parts shellac, 12 mastic, 4 turpentine, 6 verdigris; colored with a mixture of yellow and indigo.

2325. To Make Perfumed Sealing-Wax. Any fine sealing-wax may be perfumed by mixing 1 per cent. of balsam of Peru, or liquid storax, to the ingredients when considerably cooled. A little essence of musk or ambergris will serve the same purpose. The addition of a little camphor or spirit of wine makes sealing-wax melt easier.

2326. To Improve the Appearance of Common Sealing-Wax. To make common sealing-wax appear to better advantage, the sticks, being still soft, are dipped in the powder of a better quality, and then superficially melted, so as to produce a thin coating.

2327. Soft Sealing-Wax for Diplomas. Take 16 parts yellow wax, 3 turpentine, 1 olive oil; after it is melted, the cinnabar, or other coloring matter, is stirred in the compound.

2328. To Take Proof-Impressions of Seals and Stamps. For this purpose the very best sealing-wax is melted as usual by a flame, and carefully worked on the surface to which it is applied, until perfectly even; the stamp is then firmly and evenly pressed into it. The flame of a spirit lamp is preferable, having no tendency to blacken the wax. A beautiful dead appearance is given to the impression by dusting the stamp, before using it, with a finely-powdered pigment of the same color as the wax; thus, for vermilion sealing-wax, powdered vermilion, &c.

Glass. This is a compound of silica (silicic acid) with the oxide of an alkaline metal, obtained by fusion. In its usual form it is brittle, transparent, non-crystalline, insoluble, and fusible; but it sometimes exhibits other qualities. The principle of its production is very simple, although skill and experience are necessary to insure excellence. Silica (commonly under the form of sand) is heated with carbonate of potassa or soda and slaked lime or oxide of lead, until the mixture fuses and combination takes place. When the mass becomes perfectly limpid and free from air bubbles, it is allowed to cool until it assumes the peculiar tenacious condition for working. The fusion is performed in large crucibles of refractory fire-clay; in making lead glass, the crucible is covered with a dome, and an opening left in the side, through which the materials are put in and the melted glass withdrawn. Carbonates and other crystalline matter used in glass making, require to be *dry.* (*See No.* 2065.) Certain mineral oxides give glass a variety of color, sometimes of a very undesirable kind. Should the paste contain traces of iron, instead of producing white glass there will be only the common bottle-glass; and if the iron be in larger proportions, the dark green shade will be the result. On the contrary, add a certain quantity of oxide of lead to a pure base of potash, and the beautiful crystal glass is formed; a still larger dose, and the diamond paste, with its wonderfully dispersive power, will deceive many an unpracticed eye.

2340. Peligot's Bohemian Tube Glass. The component parts of this glass are 71½ parts quartz, 20 parts *dry* (*see No.* 2065) carbonate of potassa (or its equivalent), 8½ parts quicklime, and a little manganese. It is very intractable and difficult to melt, but the addition of a very small quantity of borax, boracic acid, or arsenious acid, causes it to flow into a glass of great brilliancy and hardness, and capable of being wrought at the highest heat of the ordinary furnace.

2341. Bottle Glass. *Dry* Glauber salts, 11 pounds; soaper salts, 12 pounds; ½ bushel of waste soap ashes; sand, 56 pounds; glass skimmings, 22 pounds; green broken glass, 1 cwt.; basalt, 25 pounds. This mixture affords a dark green glass. Or: Yellow or white sand, 100 parts; kelp, 30 to 40 parts; lixiviated wood ashes, from 160 to 170 parts; fresh wood ashes, 30 to 40 parts; potter's clay, 80 to 100 parts; cullet, or broken glass, 100 parts. If basalt be used, the proportion of kelp may be diminished.

2342. Broad, or Green Window Glass. *Dry* Glauber salts, 11 pounds; soaper salts, 10 pounds; ½ bushel of lixiviated soap waste; 50 pounds of sand; 22 pounds of glass-pot skimmings; 1 cwt. of broken green glass.

2343. Crown, or White Window Glass. Pure sand, 100 parts; dry sulphate of soda, 50 parts; dry quicklime, in powder, 17 to 20 parts; charcoal, 4 parts. The product is white and good.

2344. Bohemian Crown Glass. Pure silicious sand, 63 parts; potash, 22 parts; lime, 12 parts; oxide of manganese, 1 part.

2345. Nearly White Table Glass. Take 20 pounds potashes, 11 pounds dry Glauber salts, 16 pounds soaper salt, 55 pounds sand, and 140 pounds cullet or broken glass of the same kind. Or: 100 parts sand, 235 kelp, 60 wood ashes, 1½ manganese, 100 broken glass.

2346. White Table Glass. Fuse together 40 pounds potashes, 11 chalk, 76 sand, ½ part manganese, 95 white cullet. Or: 50 parts purified potashes, 100 sand, 20 chalk, and 2 saltpetre.

2347. Crystal Glass. Take 60 parts purified potashes, 120 sand, 24 chalk, 2 saltpetre, 2 arsenious acid, 1/12 part manganese. Or: Purified pearlashes, 70 parts; 120 white sand; 10 saltpetre; ½ part arsenious acid; and ½ part manganese. Or: 67 parts sand, 23 purified pearlashes, 17 sifted slacked lime, ½ part manganese, 5 to 8 red lead.

2348. Clear Crystal Glass. White sand, 15 parts; red lead, 10 parts; refined ashes, 4 parts; nitre, 1 part; arsenious acid and manganese, of each a very little.

2349. Vienna Plate Glass. Sand, 100 parts; calcined sulphate of soda, 50 parts; lime, 20 parts; charcoal, 2½ parts.

2350. Plate Glass. Pure sand, 40 parts; *dry* carbonate of soda, 26½ parts, lime, 4 parts; nitre, 1½ parts; broken plate glass, 25 parts.

2351. French Plate Glass. White quartz sand and cullet (old glass), of each 300 parts; *dry* carbonate of soda, 100 parts; slacked lime, 43 parts. Or: Pure sand, 72 parts; refined soda, 45 parts; quicklime, 48 parts; nitre, 2½ parts; cullet (old glass), 45 parts.

2352. Table of Proportions of the Materials Used for Making Lead Glass, the Numbers Increasing with the Quality.

	Crystal.					Common Flint.			Optical.		Paste to imitate Diamonds &c.		
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Silica	100	100	100	100	100	100	100	100	100	100	100	100	100
Oxide of Lead	10	30	42	45	48	66	70	80 to 85	100	100	133	154	100
Potash, purified	35	33	33	35	16	26	40	35 to 40	23	23	13	5.6	20
Saltpetre		10	15			7	3	2 to 3		1.3			20
Carbonate of Lime	13				8								
Borax									.7	1.8		6.3	

It has been suggested that the oxide, or other salt of thallium, substituted for the lead, makes a paste of greater brilliancy and dispersive powers for optical purposes, and for imitation gems.

2353. Ingredients for Coloring Paste to Imitate Gems. The following proportions must be added to 1000 parts of paste No. 12 in the above table of lead glass.

2354. For Topaz. Antimony glass, 40 parts; and 1 part gold purple (purple of cassius, *see Nos.* 2720 to 2723.)

2355. For Ruby. A ruby color is given by 25 parts oxide of manganese.

2356. For Amethyst. Oxide of manganese, 8 parts; ½ part gold purple (*see Nos.* 2720 to 2723), and 5 parts oxide of cobalt.

2357. For Garnet. Antimony glass, 500 parts; 4 parts oxide of manganese, and 4 parts gold purple. (*See Nos.* 2720 *to* 2723.)

2358. For Sapphire. Take 15 parts oxide of cobalt.

2359. For Aqua Marine. Take 7 parts antimony glass, ½ part oxide of cobalt.

2360. For Emerald. Take 8 parts oxide of copper, ½ part oxide of chrome.

2361. To Stain or Color Glass. Different colors are given to glass by the addition of metallic oxides. Thus, for *amethyst*, oxide of manganese is used; for *blue*, oxide of cobalt; for *brown*, oxide of iron; for *green*, black oxide of copper; for *purple*, oxide of gold; for *ruby red*, suboxide of copper; for *white*, oxide of tin; for *yellow*, oxide of silver, &c. These substances are either added to the melted contents of the glass-pot, as in preparing artificial gems (*see No.* 2419), or are applied in a thin layer to the surface of the object, which is then heated until the coloring compound fuses as in enameling. (*See No.* 2378.)

2362. French Glass Used for Light-Houses. The special composition of the crown glass used for the light apparatus for light-houses was, until quite recently, kept a secret by the manufacturers of Saint Gobain, in France, and some firms in Birmingham, which had the monopoly of this branch of trade. From the researches of David M. Henderson, C. E., we are able to furnish the composition of both. The French glass is composed of silicic acid, 72.1 parts; soda, 12.2 parts; and lime, 15.7 parts; including some traces of alumina and oxide of iron.

2363. English Light-House Glass. In Birmingham it is made from 580 pounds French sand, 203 pounds carbonate of soda, 63 pounds lime, 28 pounds nitrate of soda, and 3 pounds arsenious acid. The best qualities of this glass are at present produced in the Siemens furnace.

2364. Liquid Spectroscopes. The use of transparent liquids, such as bisulphide of carbon, for the manufacture of lenses, is making rapid progress on the ground of economy;

large pieces of glass, free from flaw and blemish, being difficult to obtain, and expensive. Poggendorff's "Annalen" calls attention to possible disturbances of the accuracy of liquid prisms, the lines in the spectrum varying with the temperature. The divergence, owing to changes of heat and cold, of the lines of solid prisms, is quite insignificant. A glass prism, heated in the sun and then removed to the shade, was observed to possess an increased refractive power as it cooled, while a bisulphide prism exhibited a reversed result. These facts point out the importance of the use of the thermometer in conjunction with the spectroscope, and also show that there is room for great improvement in the manufacture of glass for optical purposes.

2365. Prismatic Diamond Crystals for Windows. A hot solution of sulphate of magnesia, and a clear solution of gum-arabic, mixed together. Lay it on hot. For a margin or for figures, wipe off the part you wish to remain clear with a wet towel.

2366. To Drill Glass. Wet an ordinary drill with petroleum or benzine; turpentine will answer, but not so well; it will then bore common glass nearly as rapidly as steel. If it is intended to bore through, the glass should be first countersunk on each side with a drill dressed off so as to form a very flat three-sided pyramid. Flint and plate-glass are very difficult to bore. It has been recently ascertained that dilute sulphuric acid is much more effective, with less wear of the tool, than oil of turpentine. It is stated that at Berlin, glass castings for pump barrels etc., are drilled, planed and bored like iron ones, and in the same lathes and machines, by the aid of sulphuric acid.

2367. To Cut Glass Round or Oval Without a Diamond. Scratch the glass around the shape you desire with the corner of a file or graver; then, having bent a piece of wire to the same shape, heat it red hot and lay it upon the scratch, sink the glass into cold water just deep enough for the water to come almost on a level with its upper surface.

2368. To Break Glass in any Required Way. Dip a piece of worsted thread in spirits of turpentine, wrap it round the glass in the direction required to be broken, and then set fire to the thread, or apply a red hot wire round the glass; if it does not immediately crack, throw cold water on it while the wire remains hot. By this means glass vessels that have been broken may often be fashioned and rendered useful for a variety of purposes.

2369. To Break a Glass Bottle or Jar Across its Circumference. Place the bottle in a vessel of water, to the height where it is designed to break it; also fill the bottle to the same level. Now pour coal oil inside and out on the water; cut a ring of paper, fitting the bottle. Saturate with alcohol or benzine, so that it touches the oil. Pour, also, some inside the bottle. Set on fire; the cold water prevents the glass from heating below its surface, while the expansion caused by the heat will break the vessel on the water line.

2370. Glass of Antimony. Roast powdered antimony in a shallow vessel over a gentle fire, until it turns whitish gray, and ceases to emit fumes at a red heat; then heat it in a crucible until it fuses into a brownish red glass. If calcined too much, a little more antimony must be added to make it run well.

2371. Writing on Glass. This may be done with a piece of French chalk, or crayons prepared for the purpose; or even with a common pen held nearly perpendicular. India ink, or, when the article will be exposed to damp, shellac varnish, thickened with a little vermilion or lampblack, for red or black color, is best adapted for the purpose. Common ink is not sufficiently opaque.

2372. To Imitate Ground Glass. A ready way of imitating ground glass is to dissolve Epsom salts in beer, and apply with a brush. As it dries it crystallizes.

2373. To Make Prince Rupert's Drops. Prince Rupert's drops are made by letting drops of melted glass fall into cold water; the drops assume by that means an oval form, with a tail or neck resembling a retort. They possess this singular property, that if a small portion of the tail is broken off, the whole bursts into powder, with an explosion, and a considerable shock is communicated to the hand that grasps it.

2374. To Etch on Glass. Etching with hydrofluoric acid on plate glass is practiced now to a very considerable extent, the French manufacturers especially producing splendid ornamental effects by this process. The drawings to be imitated or etched on the glass are first made on stone or plate and then printed on unsized paper with an ink consisting principally of a solution of asphaltum in oil of turpentine made with the aid of heat, to which some substance is added which shows a more or less crystalline structure on cooling, as stearic acid, spermaceti, naphthaline, paraffine. This mixture is strained and rapidly cooled with constant stirring; it is the only kind of coating which thoroughly resists the action of the corrosive acid. The printed paper is laid flat with the blank side on water, to which from 10 to 25 per cent. of muriatic acid has been added, and as soon as the lines show signs of softening the negative printing is transferred to the glass by a slight pressure; when the paper is removed, the picture will adhere to the glass, and this is afterwards exposed to the fluoric vapors in leaden troughs.

2375. To Etch or Write on Glass. A writer in Dingler's "Polytechnisches Journal" recommends a solution of fluoride of ammonium, which can be used with an ordinary quill, and on drying leaves a distinct line.

2376. To Engrave on Glass. To engrave on glass, fluoric acid is used, either in the liquid state or in vapor. This acid is kept in metal bottles, and requires very careful handling. The glass must be warmed, and coated with wax, or engravers' cement, and the writing or design traced through the wax with a pointed instrument. The liquid fluoric acid is poured on it, and left to act on the uncovered portions of the glass; or pour some of the acid in a small lead pan, which place in a still larger vessel filled with sand; heat the sand and place the glass object over the gas liberated from the heated acid, and it will soon be found to be beautifully etched. Great care must be taken when this is going on, for the gas, as well as the acid, is of a very deleterious character. The same effect may be produced by the use of fluorspar, powdered and made into a paste with oil of vitriol, laid over the prepared surface, and covered with lead-foil or tea-lead; or bruised fluorspar is put in a wedgwood evaporating basin, with sufficient oil of vitriol to form a thin paste, and the prepared glass laid over the basin, so that the vapors may act on the portions from which the wax has been removed.

2377. Glass of Borax. Calcine borax with a strong heat till the water of crystallization is expelled, and the salt fuses into a clear glass.

Enamels.

A species of vitreous varnish, colored by means of metallic oxides (*see No.* 2393) and applied in a thin stratum to brightly polished metallic surfaces (copper or gold), on which it is fused by the flame of a blowpipe, or by the heat of a small furnace. The basis of all enamels is a highly transparent and fusible glass, called *frit, flux,* or *paste.*

2379. Base Frit or Flux for Enamels. The precise qualities of the products of the following processes depend greatly upon the duration and degree of heat employed. By increasing the quantity of sand, glass, or flux, the enamel is rendered more fusible, and the opacity and whiteness is increased by the addition of oxide of tin. The use of borax should be avoided, or used very sparingly, as it is apt to make the enamel effloresce and lose color.

I. Red lead, 16 parts; calcined borax, 3 parts; powdered flint glass, 12 parts; powdered flints, 4 parts; fuse in a Hessian crucible for 12 hours, then pour it out into water, and reduce it to a powder in a biscuit-ware (unglazed porcelain) mortar.

II. Powdered flints, 10 parts; nitre and white arsenic, of each 1 part as last.

III. Flint glass, 3 ounces; red lead, 1 ounce; as last.

IV. Red lead, 18 parts; borax (not calcined), 11 parts; flint glass, 16 parts; as last.

V. Flint glass, 6 parts; flux No. II, above, 4 parts; red lead, 8 parts; as last.

VI. Tin, 2 to 5 parts; lead, 10 parts; calcine in an iron pot at a dull cherry-red heat, and scrape off the oxide as it forms, observing to obtain it quite free from undecomposed metal; when enough of the dross is obtained, reduce it to fine powder by grinding and elutriation (*see No.* 14), then mix 4 parts of this powder with an equal weight of pure sand or powdered flints, and 1 of sea-salt, or other alkaline matter; fuse the mixture in a Hessian crucible, and proceed as before. The best proportions of the tin and lead, for all ordinary purposes, are about 3 of the former to 10 of the latter. The calcined mixed oxides are commonly called calcine.

VII. Lead and tin, equal parts; calcine as above; and take of the mixed oxides, or calcine (*see preceding receipt*) and ground flints, of each 1 part; pure subcarbonate of potash, 2 parts; as before.

VIII. Lead, 30 parts; tin, 33 parts; calcine as before, then mix 50 parts of the calcine with an equal weight of flints, in powder, and 1 pound of salts of tartar; as before. A fine dead white enamel.

2380. Black Enamels. I. Pure clay, 3 parts; protoxide of iron, 1 part; mix and fuse. A fine black.

II. Calcined iron (protoxide), 12 parts; oxide of cobalt, 1 part; mix, and add an equal weight of white flux. (*See No.* 2396.)

III. Peroxide of manganese, 3 parts; zaffre, 1 part; mix and add it as required to white flux. Zaffre is crude oxide of cobalt.

2381. Blue Enamels. Either of the white fluxes colored with oxide of cobalt.

II. Sand, red lead, and nitre, of each 10 parts; flint glass or ground flints, 20 parts; oxide of cobalt, 1 part, more or less, the quantity depending on the depth of color required.

2382. Brown Enamels. I. Red lead and calcined iron, of each 1 part; antimony, litharge, and sand, of each 2 parts; mix and add it in any required proportion to a flux, according to the color desired. A little oxide of cobalt or zaffre is frequently added, and alters the shade of brown.

II. Manganese, 5 parts; red lead, 16 parts; flint powder, 8 parts; mix.

III. Manganese, 9 parts; red lead, 34 parts; flint powder, 16 parts.

2383. Green Enamels. I. Flux, 2 pounds; black oxide of copper, 1 ounce; red oxide of iron, ½ drachm; mix.

II. As above, but use the red oxide of copper. Less decisive.

III. Copper dust and litharge, of each 2 ounces; nitre, 1 ounce; sand, 4 ounces; flux, as much as required.

IV. Add oxide of chrome to a sufficient quantity of flux to produce the desired shade; when well managed the color is superb, and will stand a very great heat; but in careless hands, it frequently turns on the dead-leaf tinge.

V. Transparent flux, 5 ounces; black oxide of copper, 2 scruples; oxide of chrome, 2 grains. Resembles the emerald.

VI. Mix blue and yellow enamel in the required proportions.

2384. Olive Enamels. Good blue enamel, 2 parts; black and yellow enamels, of each 1 part; mix. (*See Brown Enamels.*)

2385. Orange Enamels. I. Red lead, 12 parts; red sulphate of iron and oxide of antimony, of each 1 part; flint powder, 3 parts; calcine, powder, and melt with flux, 50 parts.

II. Red lead, 12 parts; oxide of antimony, 4 parts; flint powder, 3 parts; red sulphate of iron, 1 part; calcine, then add flux, 5 parts to every 2 parts of this mixture.

2386. Purple Enamels. I. Flux colored with oxide of gold, purple precipitate of cassius (*see Nos.* 2720 *to* 2723), or peroxide of manganese.

II. Sulphur, nitre, vitriol, antimony, and oxide of tin, of each 1 pound; red lead, 60 pounds; mix and fuse, cool and powder; add rose copper, 19 ounces; zaffre, 1 ounce; crocus martis, 1½ ounces; borax, 3 ounces; and 1 pound of a compound formed of gold, silver, and mercury; fuse, stirring the melted mass with a copper rod all the time, then place it in crucibles, and submit them to the action of a reverberatory furnace for 24 hours. This is said to be the purple enamel used in the mosaic pictures of St. Peter's at Rome.

2387. Dark Red Enamel. Sulphate of iron (calcined dark), 1 part; a mixture of 6 parts of flux IV. (*in No.* 2379) and 1 of colcothar, 3 parts.

2388. Light Red Enamel. Red sulphate of iron, 2 parts; flux 1 (*in No.* 2379) 6 parts; white lead, 3 parts. Light red.

2389. Red Enamel. Paste or flux colored with the red or protoxide of copper. Should the color pass into the green or brown, from the partial peroxidizement of the copper, from the heat being raised too high, the red color may be restored by the addition of any carbonaceous matter, as tallow, or charcoal.

2390. Beautiful Red Enamel. The most beautiful and costly red, inclining to the purple tinge, is produced by tinging glass or flux with the oxide or salts of gold, or with the purple precipitate of cassius (*see Nos.* 2720 *to* 2723), which consists of gold and tin. In the hands of the skillful artist, any of these substances produce shades of red of the most exquisite hue; when most perfect, the enamel comes from the fire quite colorless, and afterwards receives its rich hue from the flame of the blow-pipe.

2391. Rose Colored Enamels. Purple enamel, or its elements, 3 parts; flux, 90 parts; mix, and add silver-leaf or oxide of silver, 1 part or less.

2392. Transparent Enamels. Either of the first five fluxes in No. 2379.

2393. Violet Enamels. Saline or alkaline frits or fluxes colored with small quantities of peroxide of manganese. As the color depends on the metal being at the maximum of oxidation, contact with all substances that would abstract any of its oxygen should be avoided. The same remarks apply to other metallic oxides.

2394. Yellow Enamels. Superior yellow enamels are less easily produced than most other colors; they require but little flux, and that mostly of a metallic nature. I. Red lead, 8 ounces; oxide of antimony and tin, calcined together, each 1 ounce; mix, and add flux IV. (*in No.* 2379), 15 ounces; mix and fuse. By varying the proportion of the ingredients, various shades may be produced.

II. Lead, tin ashes, litharge, antimony, and sand, each 1 ounce; nitre, 4 ounces; mix, fuse, and powder, and add the product to any quantity of flux, according to the color required.

III. Flux fused with oxide of lead, and a little red oxide of iron.

IV. Pure oxide of silver added to the metallic fluxes. The salts of silver are also used, but are difficult to manage. If a thin film of oxide of silver be spread over the surface of the enamel to be colored, exposed to a moderate heat, then withdrawn, and the film of reduced silver on the surface removed, the part under will be found tinged of a fine yellow.

2395. Bright Yellow Enamel. White oxide of antimony, alum, and sal ammoniac, each 1 part; pure carbonate of lead, 1 to 3 parts, as required, all in powder; mix, and expose to a heat sufficiently high to decompose the sal ammoniac.

2396. Dead-White Enamel. For white enamel, the articles must be perfectly free from foreign admixture, as this would impart a color. When well managed, either of the following forms will produce a paste that will rival the opal. Calcine (from 2 parts of tin and 1 part of lead calcined together), 1 part; fine crystal or frit, 2 parts; a very trifling quantity of manganese; powder, mix, melt, and pour the fused mass into clean water; dry, powder, and again fuse, and repeat the whole process 3 or 4 times, observing to avoid contamination with smoke, dirt, or oxide of iron.

2397. Fine White Enamel. Washed diaphoretic antimony, 1 part; fine glass (perfectly free from lead), 3 parts; mix, and proceed as before.

2398. To Make Black Enamel for Gold or Silver. Melt together in a crucible, 1 part, by weight, of silver, 5 parts copper, 7 parts lead, and 5 parts muriate of ammonia. Add to this mixture twice its quantity of pulverized sulphur, covering the crucible immediately. Let it calcine until the excess of sulphur has passed off. Then pound the compound to coarse powder and make it into a paste with a solution of muriate of ammonia. This is the black enamel used for jewelry.

2399. To Black Enamel Gold or Silver. Place some of the enamel paste, as prepared in the preceding receipt, on the article to be enameled; hold it over a spirit lamp until the enamel melts and flows upon it. It may then be smoothed and polished.

2400. Black or Enameled Copper. The beautiful enameled surface possessed by paintings on copper, may be produced, on a black ground, by the following process: Clean the copper with sand and sulphuric acid, and then apply the following mixture: 2 parts white arsenic, 4 parts hydrochloric acid, 1 sulphuric acid, and 24 water.

2401. Enamel for Labels, Signboards, etc. The fine enamels of trade are generally prepared by fusing at high temperatures, silica, oxide of tin, and oxide of lead, and spreading the mixture over the surface of a sheet of copper, gold, or platinum. The objections to these enamels are, in the first place their high cost, and secondly the impossibility of giving them a perfectly flat surface. Mr. E. Duchemin has advantageously replaced them by the following economical and efficient compound:

2402. Duchemin's Enamel for Labels, etc. Arsenic, 30 parts by weight; saltpetre, 30 parts; silica (fine sand), 90 parts; litharge, 250 parts. This is spread on plates of glass of the required shape and size, care being taken, however, that the kind of glass employed be not inferior in point of fusibility to the enamel. Enameled glass prepared from the above substances may be drawn or written on as readily as if it were paper, and in less time than one minute the writing may be rendered indelible by simply heating the plate in a small open furnace or muffle. Drawings, autographs, legal acts, public documents, historical facts and dates of importance, labels for horticultural purposes or destined for out-of-door exposure, coffin plates, signboards, show-case signs, etc., may thus be cheaply made, which will resist atmospheric influences for ages. First-class photographs, either positives or negatives, may be taken on such enamels without collodion. (*See Photographs on Enamel.*)

2403. Enamel for Iron Hollow Ware. The enamel of iron hollow ware is made of powdered flints, ground with calcined borax, fine clay, and a little feldspar. This mixture is made into a paste with water and brushed over the pots after they have been scoured with diluted sulphuric acid and rinsed clean with water. While still moist they are dusted over with a glaze composed of feldspar, carbonate of sodium, borax, and a little oxide of tin. Thus prepared, the pots are gradually dried and then the glaze is fired or fused under a muffle at a bright red heat. Oxide of lead, although increasing the fusibility of the glaze, impairs its efficiency, as it will not resist the action of acids in cooking.

Glazes.

Glazes must be reduced to a very fine powder. For use they are ground with water to a very thin paste or smooth cream, into which the articles, previously baked to the state called "*biscuit*," are then dropped; they are afterwards exposed to a sufficient heat in the kiln to fuse the glaze. Another method of applying them is to immerse the *biscuit* in water for a minute or so, and then to sprinkle the dry powder over the moistened surface.

2405. White Glazing. Prepare an intimate mixture of 4 parts massicot (*see Index*), 2 parts tin ashes, 3 of crystal glass fragments, and ½ part sea salt. The mixture is suffered to melt in earthenware vessels, when the liquid flux may be made use of.

2406. Yellow Glazing. Take equal parts of massicot, red lead, and sulphuret of antimony. Calcine the mixture and reduce it again to powder, add then 2 parts of pure sand and 1½ parts of salt. Melt the whole.

2407. Green Glazing. Sand, 2 parts; 3 parts massicot, 1 part of salt and copper scales, according to the shade to be produced. The mixture is melted as directed above.

2408. Violet Glazing. Massicot, 1 part; 3 parts sand, 1 of smalt, and ½ part black oxide of manganese.

2409. Blue Glazing. White sand and massicot, equal parts, ½ part of blue smalt.

2410. Black Glazing. Black oxide of manganese, 2 parts; 1 of smalt, 1½ of burned quartz, and 1½ massicot.

2411. Brown Glazing. Take 1 part broken green bottle glass, 1 of manganese, and 2 parts lead glass.

2412. Glaze without Lead. Common earthenware is glazed with a composition containing lead, on which account it is unfit for many purposes. The following glaze has been proposed, among others, as a substitute: 100 parts washed sand, 80 parts purified potash, 10 of nitre, and 20 of slacked lime, all well mixed, and heated in a black-lead crucible, in a reverberatory furnace, till the mass flows into a clear glass. It is then to be reduced to powder. The goods to be slightly burnt, dipped in water, and sprinkled with the powder.

2413. Glaze for Porcelain. Feldspar, 27 parts; borax, 18 parts; Lynn sand, 4 parts; nitre, 3 parts; soda, 3 parts; Cornwall china-clay, 3 parts. Melt together to form a frit, and reduce it to a powder with 3 parts calcined borax.

2414. Metallic Lustres for Pottery. The appearance of a lustrous metallic surface is given to vessels of stoneware, &c., by applying the lustre over an easily-fusible glaze to the outer surface of the vessel, after which adhesure is produced by exposing it to a slight degree of heat. They are then polished with cotton or leather. The principal lustres are given in the following receipts:

2415. Gold Lustre. Dissolve 1 drachm grain-gold in ¼ ounce aqua-regia, add 6 grains metallic tin to the solution. When dissolved, pour it gradually, with constant stirring, into a mixture of ⅛ drachm balsam of sulphur, (*see Index*), and 20 grains oil of turpentine. When the mass begins to stiffen, an additional ¼ drachm oil of turpentine must be added and well mixed in. More gold deepens and brightens the lustre; more tin turns it on the violet or purple. Applied as in No. 2414.

2416. Iron Lustre. This is a mixture of muriate of iron and spirit of tar. Used according to No. 2414.

2417. Platinum Lustre. To bichloride of platinum (a solution of platina in aqua-regia), is added drop by drop a mixture of spirit of tar and balsam of sulphur in equal proportions, until by a trial the composition is found to give the required result. This gives the appearance of polished steel. (*See No.* 2414.)

2418. Silver Lustre. Reduce ammonio-chloride of platinum to an impalpable powder; grind it to the requisite consistence with a little spirit of tar, and apply with a brush as directed in No. 2414.

Artificial Gems.

These consist of vitreous compounds made in imitation of gems and precious stones. Like enamels, the artificial gems have for their basis a very fusible, highly transparent and brilliant dense glass, which is known under the name of *frit, paste, strass, mayence base,* &c., and which, in its state of greatest excellence, constitutes the artificial diamond. As the strass or base enters largely into the manufacture of imitation gems, we give the method for making it first. It is absolutely necessary, to ensure success in the following receipts, that the substances employed be perfectly free from impurities, particularly those of a mineral nature. Litharge, oxide of lead, and carbonate of lead especially, must be entirely free from oxide of tin, as the smallest particle of this imparts milkiness to the paste. All the ingredients must be separately reduced to powder; and, after being mixed, sifted through lawn. For the finer kinds of mock diamonds, rock crystal should alone be employed; when sand is used, the purest white variety should be selected, and be washed thoroughly, first with muriatic acid and then with water, to remove any traces of earthy matter. Much of the minute detail in making artificial gems can only be acquired by experience. The fusion must be carefully conducted and continuous, and the melted mass allowed to cool very slowly, after having been left in the fire for 24 to 30 hours at least. Hessian crucibles are preferred for this purpose, and the heat of an ordinary porcelain kiln is usually sufficient; but a small wind-furnace, devoted exclusively to the purpose, is in general more convenient. It is found that the more tranquil, continuous and uniform the fusion, the denser and clearer is the paste, and the greater its refractive power and beauty. All the colored vitreous compounds noticed as enamels (*see No.* 2378, *&c.*) may be worked up in this way into ornamental stones. It may be further observed that the beauty of pastes or imitation gems, and especially the brilliancy of mock diamonds, is greatly dependent on the cutting, setting up, and the skillful arrangement of the foil or tinsel behind them. (*See* ENAMELS, *No.* 2378, *&c.*; FOILS, *No.* 2447, *&c.*)

2420. Diamond Paste, or Strass. Litharge, 20 parts; silica, 12 parts; nitre and borax, each 4 parts; white arsenic, 2 parts; powder mix, fuse in a crucible, pour the melted mass into water, separate any reduced lead, and again powder and re-melt.

2421. Mayence Base, or Strass. Silica (quartz, flint or rock crystal), 8 ounces; salt of tartar, 24 ounces; mix, bake, cool, wash with dilute nitric acid, and afterwards with water; dry, powder, add 12 ounces pure carbonate of lead, and to every 12 ounces of the mixture add borax, 1 ounce; triturate in a porcelain mortar, melt in a clean crucible, and pour the fused compound into cold water; dry, powder, and repeat the process a second and a third time in a clean crucible, observing to separate any revived lead. To the third frit add nitre, 5 drachms, and again melt. Very brilliant. Or: Carbonate of lead, 8 ounces; powdered borax, 2 ounces; rock crystal, 3 ounces; manganese, ⅛ grain; mix, and proceed as last.

2422. Patent Base for Artificial Gems. The base of these gems, as patented by the Superintendent of the Royal Porcelain Works at Berlin, is a flux obtained by melting together 6 drachms carbonate of soda, 2 drachms burnt borax, 1 drachm saltpetre, 3 drachms minium, and 1½ ounces purest white sand.

2423. Loysel's Strass or Paste. Pure silex (flint or quartz), 100 parts; red oxide of lead (minium), 150 parts; calcined potash, 30 to 35 parts; calcined borax, 10 parts; arsenious acid, 1 part. This produces a paste which has great brilliancy and refractive and dispersive powers, and also a similar specific gravity to the oriental diamond. It fuses at a moderate heat, and acquires the greatest brilliancy when re-melted, and kept for 2 or 3 days in a fused state, in order to expel the superabundant alkali, and perfect the refining.

2424. Fontanier's Base for Artificial Gems. Mix together 8 ounces pure silica and 24 ounces salt of tartar; bake, cool, wash with dilute nitric acid, and afterwards with water; dry, powder, add 12 ounces pure carbonate of lead, and to every 12 ounces of the mixture add borax, 1 ounce; triturate in a porcelain mortar, melt in a clean crucible, and pour the fused compound into cold water; dry, powder, and repeat the process a second and a third time in a clean crucible, observing to separate any revived lead. To the third frit add nitre, 5 drachms, and again melt. The product is perfectly limpid and extremely brilliant.

2425. Douault-Wiéland's Paste or Strass. Rock crystal, 4056 grains; minium, 6300 grains; potash, 2154 grains; borax, 276 grains; arsenic, 12 grains. Or: Sand, 3600 grains; pure carbonate of lead, 8508 grains; potash, 1260 grains; borax, 360 grains; arsenic, 12 grains.

2426. Lançon's Paste or Strass. Litharge, 100 grains; silex, 75 grains; white tartar or potash, 10 grains.

2427. Red Cornelian. Strass, 2 pounds; glass of antimony, 1 pound; calcined peroxide of iron (rouge), 2 ounces; manganese, 1 drachm.

2428. White Cornelian. Strass, 2 pounds; washed yellow ochre, 2 drachms; calcined bones, 1 ounce.

2429. Oriental Garnet or Carbuncle. Paste 512 grains paste, 256 grains glass of antimony, 2 grains purple of cassius, and 2 grains oxide of manganese. Or: 350 grains paste, 178 grains glass of antimony, and 2 grains oxide of manganese.

2430. Vinegar Garnet. Take 2 pounds paste, 1 pound glass of antimony, and ⅛ ounce oxide of iron.

2431. Opal. Take 1 ounce paste, 10 grains horn silver, 2 grains calcined magnetic ore, 26 grains calcined bones. Or: 10 pounds paste, and ½ pound calcined bones.

2432. Ruby. Take 40 parts paste, and 1 part oxide of manganese. Or: 1 part topaz paste that has turned out opaque, and 8 parts strass; fuse for 30 hours, cool, and fuse small pieces before a blow-pipe. Or: 8 ounces strass, 84 grains each precipitate of cassius (*see Nos.* 2720 *to* 2723), peroxide of iron, golden sulphuret of antimony, and manganese calcined with nitre; add 1 ounce or more of rock crystal. Or: 1 pound paste and 3 drachms purple of cassius. Or: 4 ounces paste, 4 ounces glass of antimony, and ¼ drachm purple of cassius; this turns on the orange.

2433. Sapphire. Fuse 1152 parts paste and 68 parts oxide of cobalt for 30 hours in a luted Hessian crucible. Or: 8 ounces paste and 49 grains oxide of cobalt. A little manganese may be added to this last receipt.

2434. Topaz. Melt 95 grains paste and 1 grain calcined peroxide of iron. Or: 1008 grains paste, 43 grains glass of antimony, and 1 grain purple of cassius. (*See Nos.* 2720 *to* 2723.)

2435. Turquois. Take 10 pounds blue paste, ¼ pound calcined bones.

2436. Yellow Diamond. Take 1 ounce strass, and 10 grains glass of antimony. Or: 1 ounce strass and 24 grains chloride of silver.

2437. Chrysolite. Strass, 5 pounds; calcined peroxide of iron, 3 to 4 drachms.

2438. Eagle Marine. Paste of strass, 10 pounds; copper highly calcined with sulphur (copper-stain), 3 ounces; zaffre, 1 scruple.

2439. Emerald. Lançon's paste (*see No.* 2426), 9512 grains; acetate of copper, 72 grains; peroxide of iron, 1½ grains. Or: Douault-Wiéland paste (*see No.* 2425), 4608 grains; green oxide of copper, 42 grains; oxide of chrome, 2 grains. Or: Paste, 1 ounce; glass of antimony, 20 grains; oxide of cobalt, 3 grains. Or: Paste, 15 ounces; carbonate of copper, 1 drachm; glass of antimony, 6 grains.

2440. Lapis Lazuli. Paste, 10 pounds; calcined horn or bones, 12 ounces; oxides of cobalt and manganese, of each, ½ ounce; mix. The golden veins are produced by painting them on with a mixture of gold powder, borax, and gum water, and gently heating till the borax fluxes.

2441. Amethyst. Take 500 grains paste, 3 grains oxide of manganese, and 2 grains oxide of cobalt. Or: 4608 grains paste, 36 grains oxide of manganese, 24 grains oxide of cobalt, and 1 grain purple of cassuis. (*See Nos.* 2720 *to* 2723.) Or: 9216 grains paste, 15 to 24 grains oxide of manganese, and 1 grain oxide of cobalt.

2442. Aqua Marina, or Beryl. Take 3200 grains paste, 20 grains glass of antimony, and 1 grain oxide of cobalt. Or: 2304 grains paste, 16 grains glass of antimony, and 1 grain oxide of cobalt.

2443. Aventurine, or Gold Stone. Fuse 10 grains scales of iron, 50 grains paste, and 5 grains protoxide of copper, until the copper is reduced to metallic form, then allow the mass to cool very slowly, so that the minute crystals of metal become equally diffused through it. By substituting oxide of chromium for the protoxide of copper, the stone appears brown, filled with minute gold spangles; or by using a less quantity of the chromium, a greenish gray stone, filled with green spangles, is produced.

2444. Parisian Diamonds. These beautiful imitations of the gem are merely fused oxide of tin. It is a pity that their brilliancy is not permanent, as they become quite dull in time.

2445. Boettger's Artificial Rubies. Moisten recently precipitated and well washed hydrate of alumina, with a few drops of neutral chromate of potassa, and kneaded so that the mass assumes a scarcely perceptible tinge; then roll it out into small sticks, about the thickness of a finger, and dry them slowly, filling up any cracks that may occur in drying with fresh hydrate of alumina. When perfectly dry, warm a stick a little, and bring a portion into the end of the flame of a compound (oxyhydrogen) blow-pipe. In a few minutes several minute balls form, of such intense hardness as to scratch quartz, glass, and granite. These, however, when cut and polished, appear slightly opaque.

2446. Boettger's Artificial Emerald. This is made in the same manner as his rubies, by employing nitrate of nickel instead of the chromate of potassa. The same plan, substituting oxide of chromium for chromate of potassa, will produce gems of considerable hardness and beauty, though slightly opaque; which may, however, be lessened by the addition of a very little silica.

Inks.

Writing inks might be included under the general term of liquid coloring matters, were it not that they require to have the special characteristics of brilliance, permanence, and some degree of indestructibility, combined with perfect fluidity, in order to fulfill the objects for which they are generally used. Printing and lithographic and other inks are also included under this heading.

2461. Black Ink. According to the most accurate experiments on the preparation of black ink, it appears that the quantity of sulphate of iron should not exceed $\frac{1}{3}$ part of that of the galls, by which an excess of coloring matter, which is necessary for the durability of the black, is preserved in the liquid. Gum, by shielding the writing from the action of the air, tends to preserve the color, but if much is employed, the ink flows badly from quill pens, and scarcely at all from steel pens. The latter require a very limpid ink. The addition of sugar increases the flowing property of ink, but makes it dry more slowly, and frequently passes into vinegar, when it acts injuriously on the pen. Vinegar, for a like reason, is not calculated for the fluid ingredient. The best blue galls should alone be employed in making ink. Sumach, logwood, and oak bark, are frequently substituted for galls in the preparation of common ink. When such is the case, only about one-sixth or one-seventh of their weight of copperas should be employed.

2462. To Prevent Ink from Moulding. The addition of a few bruised cloves, or a little oil of cloves, or, still better, a few drops of creosote, will effectually prevent any tendency to mouldiness in ink.

2463. Fine Black Ink. Aleppo galls (well bruised), 4 ounces; clean *soft* water, 1 quart; macerate in a clean corked bottle for 10 days, or even longer, with frequent agitation; then add $1\frac{1}{2}$ ounces gum-arabic (dissolved in a wine-glassful of water); lump sugar $\frac{1}{2}$ ounce; mix well, and afterwards further add $1\frac{1}{4}$ ounces sulphate of iron (green copperas) crushed small, agitate occasionally for 2 or 3 days, when the ink may be decanted for use; but it is better if left to digest together for 2 or 3 weeks. When time is an object, the whole of the ingredients may be at once put into a bottle, and the latter agitated daily, until the ink is made; and boiling water instead of cold water may be employed. The above will make 1 quart of beautiful ink, writing pale at first, but soon turning intensely black.

2464. Cooley's Superior Black Ink. Bruised Aleppo nut-galls, 12 pounds; water, 6 gallons; boil in a copper vessel for 1 hour, adding water to make up for the portion lost by evaporation; strain and again boil the galls with water, 4 gallons, for $\frac{1}{2}$ hour, strain off the liquor and boil a third time with water, $2\frac{1}{2}$ gallons, and strain; mix the several liquors, and while still hot add green copperas (sulphate of iron) coarsely powdered, 4 pounds; gum-arabic bruised small, $3\frac{1}{2}$ pounds; agitate until dissolved, and, when settled, strain through a hair sieve, and keep it in a bunged-up cask for use. This will produce 12 gallons, very fine and durable.

This ink, and that in No. 2463, are good. Cooley recommends them very highly. He says that they are very durable and limpid, and will bear dilution with nearly an equal bulk of water, and still be superior in quality to ordinary inks. Of the latter ink he says that he has writing that was executed with this kind of ink upwards of 60 years ago, which still possesses a good color.

2465. Black Ink. Campeachy logwood chips, 3 pounds; bruised galls, 9 pounds; boil in water, and to the mixed liquors add gum-arabic and green copperas, of each 4 pounds; to produce $16\frac{1}{2}$ gallons of ink. Quality very good, but inferior to the above.

2466. Asiatic Black Ink. Logwood shavings and powdered galls, of each 2 pounds; green vitriol, 1 pound; gum, $\frac{1}{2}$ pound; pomegranate bark, $\frac{1}{2}$ pound; water, 1 gallon; infuse 14 days with frequent agitation, or boil as directed in last receipt. This ink writes pale, but flows well from the pen, and soon turns black.

2467. Good Black Ink. Bruised galls, 2 pounds; logwood, green copperas, and gum, of each 1 pound; water, 6 gallons; boil the whole of the ingredients in the water for $1\frac{1}{2}$ hours, and strain 5 gallons. Good, but not fine.

2468. Common Black Ink. Bruised galls, 1 pound; logwood, 2 pounds; common gum, $\frac{3}{4}$ pound; green copperas, $\frac{1}{2}$ pound; water, 5 gallons; boil. Common, but fit for ordinary purposes.

2469. Exchequer Ink. Bruised galls, 40 pounds; gum, 10 pounds; green sulphate of iron, 9 pounds; soft water, 45 gallons; macerate for 3 weeks, employing frequent agitation. This ink will endure for centuries.

2470. Black Steel Pen Ink. A black ink, not corroding steel pens, and neutral, may be prepared by digesting in an open vessel, 42 ounces coarsely-powdered nut-galls, 15 ounces gum senegal, 18 ounces sulphate of iron (free from copper), 3 drachms aqua ammonia, 24 ounces alcohol, and 18 quarts distilled or rain water. Continue the digestion until the fluid has assumed a deep black color.

2471. Glycerine Ink. Take copperas, 4 ounces; nut-galls, 12 ounces; logwood, 8 ounces; vinegar, 8 ounces; gum-arabic, 1 ounce; glycerine, $\frac{1}{2}$ ounce; water, 48 ounces; all the solid substances are to be pulverized and boiled for an hour together; they are then set to cool, strained through a flannel bag, and after that filtered through a folded filter. A drop of oil of cloves is added, the whole well shaken and filled into bottles. This ink will copy well.

2472. Dr. Ure's Ink. For 12 gallons of ink take 12 pounds bruised galls, 5 pounds gum, 5 pounds green sulphate of iron, and 12 gallons rain water. Boil the galls with 9 gallons of the water for 3 hours, adding fresh water to supply that lost in vapor; let the decoction settle, and draw off the clear liquor. Add to it the gum previously dissolved in $1\frac{1}{2}$ gallons of water; dissolve the green vitriol separately in $1\frac{1}{2}$ gallons of water, and mix the whole.

2473. Japan Ink. Aleppo galls, $\frac{1}{2}$ pound; logwood chips and copperas, each 4 ounces; gum-arabic, 3 ounces; sugar, 1 ounce; blue vitriol (sulphate of copper), and sugar candy, each $\frac{1}{2}$ ounce. Boil the galls and logwood in 6 quarts water till reduced one-half; strain; add the other ingredients. Stir until dissolved. Clear and bottle. If it does not shine enough, add more gum; also a few cloves, to prevent mould.

2474. Ink Powder. For an ink powder take 1 pound nut-galls, 7 ounces copperas, and 7 ounces gum-arabic. Pulverize and mix. This amount of ink powder will make 1 gallon of good black ink. Two or three powdered cloves should be mixed with each pound of powder, to prevent moulding.

2475. Permanence of Ink. The great difficulty with all iron inks is the precipitation which will take place, after a longer or shorter time, and which manufacturers have tried to obviate by substituting other materials. All inks, however, the basis of which is not tannate and gallate of iron, are not black immediately, and consequently not so agreeable to the eye when using them. The alizarine or rather indigo inks leave a greenish, the chromium inks a reddish hue, and are not better adapted to withstand chemical agents than iron inks are.

2476. To Keep Ink from Thickening. The only way to keep writing ink thin with which we are acquainted is to protect it from the atmosphere. The air not only evaporates it, but oxidizes it and renders it thick. Those ink-stands which have a tapering funnel in the mouth will preserve the ink in its normal state much longer than the ordinary kind, because less of the surface is exposed.

2477. Writing Fluids. The very general use of steel pens has caused a corresponding demand for easy flowing inks, many of which have been of late years introduced under the title of "writing fluids," or "steel pen ink." These are mostly prepared from galls in the preceding manner, but a less quantity of gum is employed. The blue writing fluids, which either maintain their color or turn black by exposure, are prepared from the ferrocyanide of potassium (prussiate of potassa), or from indigo.

2478. Beautiful Blue Writing Fluid. Dissolve basic or soluble Prussian blue in pure water. This is the most permanent and beautiful ink known. It is not affected by the addition of alcohol, but is immediately precipitated by saline matter. The precipitate, however, still possesses the property of dissolving in pure water.

2479. To Test Prussian Blue. Pure Prussian blue feels light in the hand; adheres to the tongue; has a lively dark blue color, and gives a smooth deep trace. It should not effervesce with acids, as when adulterated with chalk; nor become pasty with boiling water, as when adulterated with starch. Prussian blue, rendered inferior in its color by an admixture of free oxide of iron, may be improved by digestion in dilute sulphuric or muriatic acid, washing and drying. Its relative richness in the real ferroprussiate of iron may be estimated by the quantity of potash or soda which a given quantity of it requires to destroy its blue color.

2480. Blue Writing Fluid. Dissolve the soluble ferrocyanide of potassium and iron in pure water. Resembles No. 2478, but is precipitated from its solution by alcohol.

2481. Stephens' Patent Blue Ink. *Mr. Stephens' process.* Take Prussian blue, (either of commerce, or the pure chemical combination of sesquioxide of iron with ferrocyanide of potassium), put it into any earthen vessel, and pour upon it as much strong hydrochloric, nitric, or sulphuric acid as will cover it (if sulphuric acid is used it must be diluted with an equal bulk of water); after standing 48 hours or more, add plenty of water, stirring it thoroughly, to remove the salts of iron; let it stand till all color has subsided, then draw off the clear liquid with a syphon; add fresh water, and repeat the washing until ferrocyanide of potassium ceases to produce a blue precipitate, and the water drawn off ceases to redden blue litmus paper, then filter the product. This treatment extracts much of the iron from the Prussian blue, and takes away its liability to precipitate by long standing. Next add and carefully mix 1 part oxalic acid to every 6 parts of Prussian blue; then dilute, by degrees, with water sufficient to make the blue ink any desired tint. The influences of air and dampness have a tendency to destroy the color of manuscript written with black ink, while the same influences tend to deepen and increase the color of the Prussian blue ink. This ink is only affected by continued exposure to light, which makes it fade in some degree; but it completely recovers its original depth of color by being put in a dark place.

2482. Mohr's Blue Writing Fluid. Triturate to a perfectly smooth paste, 6 parts pure Prussian blue, and 1 part oxalic acid, with a little water; then dilute with sufficient soft water to make it fluid.

2483. Runge's Black Writing Fluid. This is a cheap and good ink, and resists ordinary destructive agents well. It is perfectly liquid, scarcely thickens by age, deposits no sediment, and does not corrode steel pens. Digest ¼ pound logwood in fine chips for 12 hours in 3 pints boiling water; then simmer down gently to 1 quart, carefully avoiding dust, grease, and smoke. When cold, decant the decoction, and dissolve in it by agitation 20 grains yellow chromate of potash; it will then be fit for use.

2484. Shellac Ink, or Coathupe's Writing Fluid. To 18 ounces water add 1 ounce powdered borax and 2 ounces bruised shellac, and boil them in a covered vessel, stirring them occasionally till dissolved. Filter, when cold, through coarse filtering paper; add 1 ounce mucilage; boil for a few minutes, adding sufficient finely-powdered indigo and lampblack to color it. Leave the mixture for 2 or 3 hours for the coarser particles to subside; pour it off from the dregs, and bottle it for use.

2485. Arnold's Writing Fluid. Arnold's writing fluid is a mixture of sulphate of indigo and ordinary ink. It flows freely from the pen and at last becomes very black. On account of the large quantity of acid it contains, it is very destructive to steel pens, and for this evil we know of no cure.

2486. Blue Fluid for Making Blue-Black Writing Ink. Prussian blue in fine powder, 1 ounce placed in a common phial, and concentrated hydrochloric acid, 2 ounces, poured over it. Effervescence ensues, and the mixture soon assumes the consistence of a thin paste. After 24 hours it may be diluted with 8 or 9 ounces of water, and preserved in a glass bottle. The intensity of this color may be lessened by water. It forms an excellent blue writing fluid.

2487. Fine Writing Fluid. Dissolve ceruleo-sulphate of potassa or ammonia (soluble indigo) in hot water, and when cold decant the clear. It is an intense blue, and dries nearly black; is perfectly incorrosive, and very permanent and easy flowing. It may be thickened with gum water, or diluted with pure rain water, as required.

2488. Reade's Patent Blue Writing Fluid. Prepare a solution of iodide of iron, from iodine, iron, and water; add to the solution half as much iodine as first used. Pour this solution into a semi-saturated solution of ferroprussiate of potash, containing nearly as much of the salt as the whole weight of iodine. Collect the precipitate, wash it, and finally dissolve it in water, to form the blue ink. The solution from which the precipitate is separated, evaporated to dryness, and the residue fused, re-dissolved, and crystallized, yields pure iodide of potassa.

2489. Indelible Writing Fluid. To gall ink, add a strong solution of Reade's Patent Writing blue in distilled water. This addition makes the ink which was previously proof against alkalies, equally proof against acids, and forms a writing fluid which cannot be erased from paper by any common method of fraudulent obliteration without the destruction of the paper. This ink writes greenish blue, but afterwards turns intensely black.

2490. Precautions in Making Writing Fluids. All the preceding receipts for writing fluids, under proper management, produce excellent products. Care must be taken in all cases that the *ingredients be pure,* and unless this precaution is attended to, success is doubtful. Either of the preceding blue fluids may be used as indelible ink to mark linen, and will be found very permanent, provided the part be first moistened with alum water and dried.

2491. Gold Ink. Gold ink is prepared in the following way: Genuine gold leaf is rubbed with honey on a plate of agate or ground glass by means of a flat pestle, until the whole presents a uniform mass, in which no distinct particles of gold can be recognized. (*See No.* 2517.) This mass is carefully removed into a vessel with water, which will dissolve the honey, and leave the gold in an extremely disintegrated state behind. The water has, according to the size of the vessel, to be removed twice or three times, when all the saccharine matter will have been washed away. The remaining gold is then mixed with a sufficient quantity of a solution of gum-arabic, shaken well, and is ready for use. (*See No.* 2518.) The writing is to be rubbed, after drying, with a flat piece of ivory, when it will present the lustre of pure gold.

2492. Silver Ink. Silver ink is prepared in the same way, from silver leaf, as the gold in last receipt.

2493. Gold Labels on Glass Bottles. The finely divided gold, prepared as in No. 2491, is distributed in a solution of gum damar in naphtha, and the writing is to be done with this fluid by means of a brush. If the solution should become too thick in course of time, a little naphtha is added and well shaken, when the gold paint will be ready for use again. The gum damar in drying will cover the written lines with a kind of varnish that will protect the gold from the action of acids or alkalies.

2494. Purple Ink, or King of Purples. Infuse 12 pounds campeachy logwood in 12 gallons water; provide a funnel at the bottom of which a sponge has been placed; pour the infusion through a strainer made of coarse flannel into the funnel, and thence on to 1 pound hydrate or acetate of copper (verdigris); then add immediately 14 pounds alum; and for each 17 gallons of the liquid, add 4 pounds gum-arabic or senegal; let these remain 3 or 4 days and a beautiful purple will be produced.

2495. Green Ink. Boil 2 parts acetate of copper and 1 part bitartrate of potassa in 8 parts water, until the solution is reduced to half the bulk; filter through a cloth, and, when cool, bottle.

2496. Green Ink. Dissolve 180 grains bichromate of potassa in 1 fluid ounce of water; add, while warm, ¼ ounce spirit of wine; then decompose the mixture with concentrated sulphuric acid, until it assumes a brown color; evaporate this liquor until its quantity is reduced to one-half; dilute it with 2 ounces distilled water; filter it, add ½ ounce alcohol, followed by a few drops strong sulphuric acid; it is now allowed to rest, and after a time it assumes a beautiful green color. After the addition of a small quantity of gum-arabic, it is ready for use.

2497. Violet, Magenta, and Solferino Ink. Inks of these, and such other bright aniline colors may be made as follows: Mix 1 drachm of the proper aniline color with 1½ ounces alcohol (*see No.* 2578) in a glass or enameled iron vessel; let it stand for 3 hours. Then add 13 ounces distilled water, and subject the whole to a gentle heat until the alcohol has evaporated, that is, until no odor of alcohol is perceptible; then add 4 drachms gum-arabic dissolved in 3 ounces water. Mix and strain. As the aniline colors of commerce vary a great deal in quality, the amount of dilution must vary with the sample used, and the shade determined by trial.

2498. Heusler's Red Ink. Take 2 ounces best Brazil wood, ½ ounce pulverized alum, ½ ounce crystals of bitartrate of potassa, and 16 ounces distilled water; boil down to one half, and strain. Then dissolve in it ½ ounce gum-arabic, and add 1½ drachms cochineal dissolved in 1½ ounces alcohol of specific gravity .839.

2499. Brilliant Red Ink. Brazil wood, 2 ounces; muriate of tin, ½ drachm; gum-arabic, 1 drachm; boil down in 32 ounces water to one half, and strain.

2500. Good Red Ink. Ground Brazil wood, 8 ounces; vinegar, 10 pints; macerate for 4 or 5 days; boil in a tinned-copper vessel to one half, then add roche alum, 8 ounces; and gum, 3 ounces; dissolve.

2501. Buchner's Carmine Ink. Pure carmine, 12 grains; water of ammonia, 3 ounces; dissolve, then add powdered gum, 18 grains; ½ drachm of powdered drop lake may be substituted for the carmine where expense is an object. This makes a superb carmine ink.

2502. Fine Red Ink. Cochineal, in powder, 1 ounce; hot water, ½ pint; digest, and when quite cold, add spirit of hartshorn, ¼ pint; or liquor of ammonia, 1 ounce; dilute with 3 or 4 ounces of water; macerate for a few days longer, then decant the clear. The color of this is very fine.

2503. Redwood's Red Ink. Guarancine and liquor of ammonia, of each 1 ounce; distilled water (cold), 1 pint; triturate together in a mortar, filter, and dissolve in the solution gum-arabic ½ ounce. (*Cooley.*)

2504. To Restore Writing Effaced with Chlorine. Expose it to the vapor of sulphuret of ammonia, or dip it into a solution of the sulphuret. Or: Ferrocyanide of potassa, 5 parts; water, 65 parts. Dissolve, and immerse the paper in the fluid, then slightly acidulate the solution with sulphuric or hydrochloric acid. The method found to answer best has been to spread the ferrocyanide thin with a feather or a bit of stick cut to a blunt point. Though the ferrocyanide should occasion no sensible change of color, yet the moment the acid comes upon it, every trace of a letter turns at once to a fine blue, which soon acquires its full intensity, and is beyond comparison stronger than the color of the original trace. If, then, the corner of a bit of blotting paper be carefully and dexterously applied near the letters, so as to imbibe the superfluous liquor, the staining of the parchment may be in a great measure avoided; for it is this superfluous liquor which, absorbing part of the coloring matters from the letters, becomes a dye to whatever it touches. Care must be taken not to bring the blotting-paper in contact with the letters, because the coloring matter is soft whilst wet, and may easily be rubbed off. The acid chiefly employed is the muriatic; but both the sulphuric and nitric succeed very well. They should be so far diluted as not to be liable to corrode the parchment, after which the degree of strength does not seem to be a matter of much nicety.

2505. To make New Writing Look Old. Take 1 drachm saffron, and infuse it into ½ pint ink, and warm it over a gentle fire, and it will cause whatever is written with it to turn yellow, and appear as if of many years' standing.

2506. To Write on Greasy Paper or Parchment. Put to a bullock's gall 1 handful of salt, and ½ pint vinegar, stir it until it is mixed well; when the paper or parchment is greasy, put 1 drop of the gall into the ink, and the difficulty will be instantly obviated.

2507. To Remove Ink Blotches from Writing. When ink blotches have been formed over writing which it is desired to decipher, we are advised to brush off the spot carefully with a weak solution of oxalic acid by means of a camel's-hair pencil. In this way layer after layer of the superincumbent ink will be removed, and finally the writing itself will, in most cases, come to view. This is especially possible where some considerable interval has elapsed between the two applications of ink. As soon as the letters are visible the brushing should be continued for a time with clean water, so as to arrest the tendency of the acid solution to make a further change in the ink.

2508. Redwood's Indelible Marking Ink. Dissolve 1 ounce nitrate of silver and 1½ ounces crystallized carbonate of soda in separate portions of distilled water, and mix the solutions; collect the resulting precipitate on a filter, wash it thoroughly with distilled water, and introduce it, while still moist, into a wedgwood-ware mortar; add 8 scruples tartaric acid, and triturate the whole until effervescence has ceased; next add sufficient ammonia to dissolve the tartrate of silver; mix in 4 fluid drachms archil, 4 drachms white sugar, and 12 drachms finely-powdered gum-arabic; then add sufficient distilled water to make 6 ounces of the mixture. This ink fulfills all the conditions that a marking ink should possess: It flows freely from the pen without running or blotting; it does not require a very strong or long continued heat to develop it; when developed it is perfectly black; and it does not injure the texture of the finest fabric.

2509. Indelible Ink. The linen is first moistened with a fluid consisting of a mixture of 2 parts carbonate of soda in crystals, 2 parts gum-arabic, 8 parts water, and then dried. When quite dry, it is rubbed with a glass or smooth pebble to render it as smooth as possible, so that it may be easier to write upon. The composition of the ink itself is as follows: 1½ parts nitrate of silver, 16 parts distilled water, 2 parts gum-arabic, and ½ part sap green. The nitrate of silver is first dissolved in the distilled water, and the gum-arabic and sap green are subsequently added. It is necessary to write with a quill pen, all metallic pens except gold ones decomposing the ink. It is a good plan to trace the letters on the linen with a pencil before writing them. This and the four following receipts are by Dr. Reiman, who says that they have all been thoroughly well tried, and found effectual.

2510. Fine Marking Ink. Marking linen is most conveniently effected by using a small stiff brush and a small copper plate with perforations corresponding to the letters required. This stencil plate is laid upon the linen, and the ink is rubbed into the cut-out spaces with the brush. The following ink is of service for marking linen with a stencil plate: 2 parts nitrate of silver, 4 parts distilled water, 2½ parts gum-arabic, 3 parts carbonate of soda crystals, 5 parts liquid ammonia. The best way to prepare the ink is to first dissolve the nitrate of silver in the liquid ammonia, and the gum-arabic and soda in the distilled water. The two solutions are then mixed together and slightly warmed, when the whole mixture becomes brown. A few drops of a solution of magenta makes the ink somewhat more distinct. When this method is used, the linen requires no previous preparation.

2511. Aniline Marking Ink. Dissolve 8½ grains bichloride of copper in 30 grains distilled water, then add 10 grains common salt, and 9½ grains liquid ammonia. A solution of 30 grains hydrochlorate of aniline in 20 grains distilled water is then added to 20 grains of a solution of gum-arabic (containing 2 parts water, 1 part gum-arabic), and lastly 10 grains of glycerine. 4 parts of the aniline solution thus prepared are mixed with 1 part of the copper solution. The liquid which results has a green appearance, and may be at once employed for marking linen, since it invariably becomes black after a few days. A steel pen may be employed as well as a quill. If it is desirable not to wait so long for the appearance of the black color, a hot iron may be passed over the writing when the ink is dry, or the linen may be held over the flame of a spirit lamp, or over a hot plate, or hot water, when the black tint will readily appear. It is a good plan to put the linen, when marked, into a tepid solution of soap, which has the effect of bringing out a fine bluish tint. The ink must be so limpid that it is able to permeate the tissue of the linen, so that the marks appear on both sides. It is advisable to mix the solutions together, only when the ink has to be used. It is perfectly indelible, and so easy to write with that the finest devices may be drawn with it. This ink has the advantage of being cheaper than the ink prepared from nitrate of silver. It has also another advantage over the latter salt, viz.: that it is chemically indelible.

2512. Purple Marking Ink. A purple marking ink can be prepared by mixing 1 part bichloride of platinum with 16 parts distilled water. The place where the letters have to be written must be moistened with a solution of 3 parts carbonate of soda, 3 parts gum-arabic, and 12 parts water. The spot is then dried and made smooth. After the letters have been written with the platinum ink and become dry, the linen is moistened with a solution of 1 part chloride of tin in 4 parts distilled water, when an intense and beautiful purple-red color makes its appearance.

2513. Cheap Brown Marking Ink. A very cheap brown marking ink may be prepared from 4 parts acetate of manganese dissolved in 12 parts water. The place on the linen where the marks have to be made must be previously moistened with the following solution: 1 part yellow prussiate of potash, ½ part gum-arabic, 3 parts water. The linen, having been saturated with the above solution, is dried, and afterwards marked with the manganese solution. On the letters becoming dry, the following solution is spread over the spot with a brush: 4 parts carbonate of potash, 10 parts water. The letters then become brown, and their color cannot be removed by alkalies, nor by acids, with the exception of dilute hydrochloric acid.

2514. Carbon Ink. Genuine Indian ink rubbed down with good black ink until it will flow easily from a pen. This ink resists chlorine, and oxalic acid.

2515. Indian or Chinese Ink. The pure article can only be obtained from China. A good imitation may be made with ivory black, ground to an impalpable powder, made into a paste with weak gum-arabic water, perfumed with a few drops of essence of musk and half as much essence of ambergris, and then formed into cakes. (*See No.* 2716.)

2516. Perpetual Ink for Tombstones, &c. Equal parts of Trinidad asphaltum and oil of turpentine. Use in a melted state to fill in the letters and devices on tombstones, &c. Without actual violence it will last as long as the stone.

2517. To Pulverize Gold and Silver Leaf. This is effected by grinding upon a porphyry slab, with a muller, gold or silver leaves with white honey, until they are reduced to the finest possible state of division. Then wash the honey thoroughly from the powdered metal and mix with gum water. (*See also No.* 25.)

2518. Liquid Gold, for Vellum, &c. Take gold leaf and grind it with gum water; then add a small quantity of bichloride of mercury, and bottle for use.

2519. Liquid Silver, for Vellum, &c. Take silver leaf and grind it with gum-water or glaire of egg.

2520. Copying Ink. The virtue of copying ink consists in its non-drying property. This property may be given to any ordinary ink by the addition of sugar. Lately, however, glycerine has been substituted for sugar, and is decidedly to be preferred. A good copying ink may be made from common violet writing ink, by the addition of about 1 part glycerine to 100 parts of the ink. The addition of too large a proportion of glycerine is apt to impair the requisite drying qualities of the ink; and too little will fail to make the ink susceptible of a perfect copy. (*See No.* 2471.)

2521. Ink for Marking Packages. Take lampblack and mix thoroughly with sufficient turpentine to make it thin enough to flow from the brush. Powdered ultramarine, instead of lampblack, makes a fine blue marking mixture for the same purpose.

2522. Ink for Marking Packages. An excellent and very cheap ink is made by mixing ¼ ounce bichromate of potassa and 4 ounces extract of logwood in a stone jar or demijohn, with 2 gallons of hot water. Shake well and let it stand for about 2 weeks, shaking occasionally.

2523. Permanent Ink for Writing in Relief on Zinc. Bichloride of platinum, dry, 1 part; gum-arabic, 1 part; distilled water, 10 parts. The letters traced upon zinc with this solution turn black immediately. The black characters resist the action of weak acids, of rain, or of the elements in general, and the liquid is thus adapted for marking signs, labels, or tags which are liable to exposure. To bring out the letters in relief, immerse the zinc tag in a weak acid for a few moments. The writing is not attacked while the metal is dissolved away.

2524. Ink for Zinc Labels. Take 1 drachm of verdigris, 1 drachm sal ammoniac powder, and ½ drachm lampblack, and mix them with 10 drachms water; and this will form an indelible ink for writing on zinc.

2525. To Write on Silver with a Black that will Never Go Off. Take burnt lead and pulverize it. Incorporate it next with sulphur and vinegar, to the consistency of a paint, and write with it on any silver plate. Let it dry, then present it to the fire so as to heat the work a little, and it is completed.

2526. Indestructible Inks. Employed for writing the labels on bottles containing strong acids and alkaline solutions. They are capable of resisting the action of iodine, chlorine, alkaline lyes and acids, as well as operations of dyeing and bleaching, besides being an excellent and cheap material for marking linen, as nothing will remove them without destroying the fabric.

2527. Hausmann's Indestructible Ink. Mix 1 part genuine Trinidad asphaltum with 4 parts oil of turpentine; color with a sufficiency of plumbago, for black, or vermilion for red ink.

2528. Close's Indestructible Ink. Mix 25 grains powdered cobalt and 200 grains oil of lavender by a gentle heat; color with 3 grains lampblack and 1 grain indigo, both in fine powder. If a red color is required, omit the lampblack and indigo and add sufficient vermilion to make the mixture a good color.

2529. Indestructible Writing Ink. Shellac, 4 parts; borax, 2 parts; soft water, 36 parts; boil in a close vessel till dissolved; then filter, and take of gum-arabic, 2 parts; soft water, 4 parts. Dissolve, and mix the two solutions together, and boil for 5 minutes as before, occasionally stirring to promote their union; when cold, add a sufficient quantity of finely powdered indigo and lampblack to color; lastly, let it stand for 2 or 3 hours, until the coarser powder has subsided, and bottle for use. Use this fluid with a clean pen, and keep it in glass or earthen inkstands, as many substances will decompose it while in the liquid state. When dry it will resist the action of water, oil, turpentine, alcohol, diluted sulphuric acid, diluted hydrochloric acid, oxalic acid, chlorine, and the caustic alkalies and alkaline earths.

2530. Simple Carbon Ink. Dissolve 30 grains of sugar in 30 grains of water, to which add a few drops of concentrated sulphuric acid. Upon heating this mixture the sugar becomes carbonized by the acid, and when applied to the paper it leaves a coating of carbon which cannot be washed off. This stain is rendered more perfect by the decomposing action of the ink itself upon the paper, and thus resists the action of chemical agents.

2531. Drawing Ink. A very black and indelible drawing ink may be made by dissolving shellac in a hot water solution of borax, and rubbing up in this solution a fine quality of Indian ink. After using, dip the drawing pen in alcohol, and wipe dry to keep it clean and bright. (*See No.* 2514.)

2532. Permanent Ink for Use with Stamps or Type. Mix equal parts black oxide of manganese and hydrate of potash, heat to redness, and rub with an equal quantity of smooth white clay into a paste, water being added for the purpose. Or: Sulphate of manganese, 2 drachms; lampblack, 1 drachm; powdered loaf sugar, 4 drachms; rubbed into paste with water. After stamping, dry the linen and wash well in water.

2533. Sympathetic, or Invisible Inks, for Secret Writing. These are colorless inks which require the aid of heat or some other agency to develop the characters written with them. Their use has been rendered specially practical since the recent introduction of the postal correspondence cards in England and elsewhere. By previous arrangement between correspondents, the receiver of a card only needs some *visible sign* on the card to identify the writer or sender; this will at once suggest the means to be employed to develop the particular ink the receiver's correspondent has agreed to use.

2534. Black Sympathetic Inks. Writing with a solution of sugar of lead will be turned black by moistening the paper with sulphide of potassium.

If nitrate of silver be used, the writing will become black by dipping the paper in a solution of ammonia.

Chloride of mercury will turn black when wetted with chloride of tin.

A weak infusion of galls is turned black by sulphate of iron (copperas).

Reversing the above, writing with copperas turns black by moistening with infusion of galls.

2535. Blue Sympathetic Inks. Writing with copperas turns blue if wetted with a solution of prussiate of potassa.

Nitrate of cobalt turns blue on being wetted with a weak solution of oxalic acid.

Rice water or a solution of boiled starch turns blue in a solution of iodine in weak spirit.

2536. Brown Sympathetic Ink. A diluted solution of nitrate of silver turns brown by exposure to the sunlight.

2537. Yellow Sympathetic Ink. Chloride of antimony, used as the ink, will become yellow by moistening with a decoction of galls.

2538. Green Sympathetic Ink. Arseniate of copper, washed over with nitrate of copper, turns a beautiful green.

2539. Purple Sympathetic Ink. Purple is produced by using chloride of gold, and soaking in chloride of tin.

2540. Sympathetic Inks Developed by Heat. There are a number of colorless substances that may be used as inks, which are developed by the application of heat only.

Sulphate of copper and sal ammoniac, mixed in equal parts, will become yellow if exposed to the fire.

Onion juice has the same property as the above mixture.

Lemon juice, a very weak solution of either aquafortis, oil of vitriol, common salt, or saltpetre, will turn yellow or brown on exposure to the fire.

A weak solution of chloride of cobalt and chloride of nickel is turned a beautiful green by heat.

A solution of chloride or nitro-muriate of cobalt, turns green when heated, and disappears again on cooling.

A dilute solution of chloride of copper becomes a fine yellow at a moderate heat, and disappears on cooling.

A solution of acetate of cobalt, with a little nitrate added to it, turns rose-colored by heat, and disappears again when cold.

These last, which disappear again on cooling, are the best sympathetic inks for purposes of correspondence, as the others are more or less indelible when once developed.

2541. Hoe's Composition for Printing Ink Rollers. This consists of glue and molasses, the proportions varying from 8 pounds of glue in summer to 4 pounds in winter, for each gallon of molasses. The glue should be placed for ½ an hour in a bucket, covered with water, then pour the water off and allow the glue to soften. Put it into a kettle and heat it until thoroughly melted; if too thick, a little water may be added. Lastly, the molasses is stirred in and well mixed with the glue. When properly prepared, an hour's boiling will be sufficient, as too much boiling is apt to candy the molasses. Pour into a clean mould well oiled with a swab.

2542. To Clean Ink Rollers. Rollers should not be washed immediately after use, as they will become dry and skinny, but they may be washed ½ hour before using again. In cleaning a new roller, a little oil rubbed over it will loosen the ink, and it should be scraped clean with the back of a knife; it should be cleaned this way for about a week, when lye may be used. New rollers are often spoiled by washing too soon with lye.

2543. Black Printing Ink. Boil 1½ gallons old clear linseed oil to the consistence of a thick varnish; whilst hot, add to it, during constant stirring, first 6 pounds powdered resin, and next 1¾ pounds dry brown soap shavings; then mix in it 2½ ounces indigo blue, 2½ ounces Paris blue, and 5 pounds best lampblack. After standing for a week it should be ground.

2544. Black or Colored Printing Ink. Balsam copaiba, 9 ounces; lampblack, 3 ounces; Paris blue, 1¼ ounces; Indian red, ¾ ounce; dry resin soap, 3 ounces. These will produce a superior black ink. By employing white soap instead of yellow, and a sufficiency of some coloring pigment instead of the black, blue, and red mixture, a good colored ink will be obtained.

2545. New Ink for Printers. A new ink for printers has been invented by Professor Artus, and Mr. Fleckstein, a master-printer at Lichtenhain, which ink is said to be a complete success. The composition of it is as follows: Venetian turpentine, 4½ ounces; fluid soap, 5 ounces; rectified oleine, 2 ounces; burnt soot, 3 ounces; Paris blue (ferrocyanic acid), ½ ounce; oxalic acid, ¼ ounce; distilled water, ½ ounce. The mixing process of this new, beautiful, and cheap ink is described as follows: Gradually warm the turpentine and the oleine together; put the soap on a marble plate, and gradually add, continually rubbing, the mixture of turpentine and oleine; when well mixed, add the burnt soot, which must first be well powdered and sifted; then add the Paris blue, dissolved in the oxalic acid, continually rubbing the composition on the stone, the Paris blue and the oxalic acid having been mixed before with water in the above given proportions. A solution of soda in water is sufficient to thoroughly cleanse the type.

2546. Indelible Printing Ink. Mix 1 pound varnish (such as is used for ordinary printing ink), 1 pound black sulphuret of mercury, 1 ounce nitrate of silver, 1 ounce sulphate of iron, 2 table-spoonfuls lampblack. Thoroughly grind together, adding enough turpentine to reduce to the requisite consistency.

2547. Lithographic Ink. Grind together 8 parts mastich, in tears, and 12 parts shellac; dissolve carefully by heat in 1 part Venice turpentine; after the mixture is taken from the fire, mix in 16 parts wax and 6 parts tallow; then add, by stirring, 6 parts hard tallow soap in shavings, and finally incorporate in the mass 4 parts lampblack. Heat and stir until thoroughly mixed; let it cool a little, and pour it out on tables, and when cold, cut into square rods.

2548. Lithographic Transfer Ink. Melt together 8 parts white wax and 2 parts white soap; and, before they become hot enough to take fire, stir in by degrees sufficient lampblack to make the mixture black; then allow the whole to burn for 30 seconds; when the flame is extinguished, add, a little at a time, 2 parts shellac, stirring it in constantly; put the vessel on the fire again until the mass is kindled, or nearly so. Put out the flame and allow it to cool a little, and then run it into the moulds. Ink thus made will make as fine or coarse lines as are desired, and its traces will remain unchanged for years before being transferred. When suet enters into the composition of lithographic crayons, it does not keep long, and requires immediate transferring to the stone.

2549. Lithographic Ink. M. Lasteyrie states that, after having tried a great many combinations, he gives the preference to the following:—Dry tallow soap, mastich in tears, and common soda in fine powder, of each 30 parts; shellac, 150 parts; lampblack, 12 parts; mix as last. Used for writing on lithographic stones.

2550. To Test the Quality of Lithographic Ink. Lithographic ink of good quality ought to be susceptible of forming an emulsion so attenuated that it may appear to be dissolved when rubbed upon a hard body in distilled or river water. It should be flowing in the pen, not spreading on the stone; capable of forming delicate traces, and very black, to show its delineations. The most essential quality of the ink is to sink well into the stone, so as to reproduce the most delicate outlines of the drawing, and to afford a great many impressions. It must, therefore, be able to resist the acid with which the stone is moistened in the preparation, without letting any of its greasy matter escape.

2551. Durable Autographic Ink. White wax, 8 ounces; and white soap, 2 to 3 ounces; melt; when well combined add lampblack, 1 ounce; mix well, and heat it strongly; then add shellac, 2 ounces; again heat it strongly; stir well together, cool a little, and pour it out. With this ink lines may be drawn of the finest to the fullest class without danger of its spreading, and the copy may be kept for years before being transferred. This ink is employed for writing on lithographic paper, and is prepared for use by rubbing down with a little water in a saucer, in the same way as common water-color cakes or Indian ink. In winter this should be done near a fire, or the saucer should be placed over a basin containing a little warm water. It may then be used with either a steel pen or a camel's-hair pencil.

Aniline Colors.

Aniline is a liquid of a color varying from yellow to dark brown. The commercial article is never chemically pure, being a mixture of pure aniline, toluidine, and odorine. Its boiling point ranges from 356° to 482° Fahr. If aniline boils at a lower temperature than 356°, it contains too much odorine, and is, therefore, of poor quality. It is obtained by conversion from nitro-benzole, a preparation of the benzole obtained from *coal tar* (not from petroleum). In preparing nitro-benzole on a large scale, 12 parts benzole are mixed with 13 parts fuming nitric acid, and 8 parts oil of vitriol, in a cast iron apparatus. The character of the product depends greatly on the purity of the benzole, and also on the management of the reaction. The conversion of nitro-benzole into aniline is, by Béchamps' process, performed in iron tanks, heated by steam, and provided with stirrers, and a still-head to collect the distillates. The tank or still is charged with 100 parts nitro-benzole, 150 clean wrought iron filings, 100 water, and 150 acetic acid; when these are mixed spontaneous heat is evolved, which causes some of the liquid to pass into the condensers, whence it is returned to the tank. As the heat is not sufficient for the complete conversion of the nitro-benzole, steam is introduced after a time, and the stirring and steaming is continued until no more nitro-benzole appears in the distilled vapor. At this point the temperature is increased, and, if necessary, aided by direct fire, to cause complete distillation of the aniline which has formed, and which passes off with water, and separates from it on standing, as the heavier stratum. The aniline used for the various colors is taken of different composition and boiling-point. A. W. Hofmann has shown that a mixture of an equivalent of aniline and two of toluidine produces the largest yield of rosaniline (fuchsine). The substance used for this manufacture begins to boil at about 347°, and as the heat increases to 390° 80 per cent. will have distilled over. Aniline blue and purple require an oil which begins to boil at 374°, and at 392° has lost only 60 per cent. Evidently with these properties it contains less aniline than the preceding one. The changes which these bases undergo when converted into dyes or compounds of rosaniline, are brought about by the partial destruction of a portion of them.

2553. Rosaniline, or Fuchsine. The principal methods for the manufacture of fuchsine employ arsenic acid, the reaction being brought about in a cast iron still with movable head, connected with a condenser, and provided with a manhole, and also a place for a thermometer. This still sits in a jacket containing a hot bath of palm-oil, which keeps it at a temperature of from 320° to 356° Fahr. A charge consists of 100 parts aniline and 200 parts arsenic acid, and the reaction is ordinarily completed in about 6 hours, sometimes in 5, but at others only in 12 hours, during which time the temperature is carefully regulated. Assays are taken from time to time, and the completion of the process is known by the pure bronze color of the sample. The fused mass is transferred to a tank, in which, after cooling, it is broken up, and at once treated with water and steam. The base fuchsine (rosaniline) dissolves, leaving behind the resinous products of the reaction; the arsenic acid is separated by the addition of milk of lime. The filtered solution, after proper concentration, deposits, on cooling, fine crystals of fuchsine, as do also the first mother liquors. An inferior quality of fuchsine is obtained by adding a portion of salt, varying in quantity.

2554. Aniline Blue. Aniline blue results from various processes. The one most commonly used at present is that of Girard and De Laire, made by heating fuchsine with fluid aniline. The original process produced a blue with a reddish tinge; but by the addition of some organic substances, acetic acid, and methylic alcohol, pure blue is obtained. It is distinguished from all other blues by not appearing green in candle light. The various shades of purple to blue and violet are made from fuchsine by Hofmann's method (*see No.* 2608), heating 1 part fuchsine and 2 iodide of ethyl with 2 parts alcohol in a closed vessel at 212° for variable lengths of time; the blue resulting from longest exposure.

2555. Aniline Green. Aniline green is produced from a solution of sulphate of rosaniline in dilute sulphuric acid and some aldehyde, which is heated till its color has changed to dark green. Addition of a solution of hyposulphite of soda separates the color.

2556. Aniline Green. Several of the aniline greens occurring in the market are apt to undergo spontaneous destruction, sometimes in less than a day. The following is a formula which any one may make: 4 parts of pure fuchsine or rosaniline are dissolved in 6 parts water and 16 parts aldehyde (*see next receipt*), and are heated at 212° Fahr., until a drop of the mixture imparts to water acidulated slightly with sulphuric acid a clear blue color, when it is ready to be poured into a boiling solution of hyposulphite of soda, which is being stirred. A fine green precipitate forms, and a grayish one, which latter must be kept separate. The green is mordanted principally with acetate of alumina.

2557. To Prepare Aldehyde. Aldehyde is made by filling a tubulated glass retort, altogether to one-third full, with 32 parts absolute alcohol, 30 parts bichromate of potassa, and, without previous cooling, a mixture of 35 parts oil of vitriol, and 30 of water, in small portions, through a safety-tube in the tubus. After one-half of the latter has been introduced, the mixture commences to boil and aldehyde begins to distill over, the remainder of the said mixture being added through the tubulus as required. No further purification is needed.

2558. To Make Aniline Colors Soluble in Water. The aniline colors insoluble in water may, according to Dr. Zinsman, be rendered soluble in the following way:—A solution of gelatine in acetic acid of about the consistence of syrup is first made, and the aniline color in fine powder is gradually added, stirring all the time so as to obtain a homogeneous paste. The mixture is then to be heated over a water-bath to the temperature of boiling water, and kept at that heat for some time. Colors in this state, if a very clear gelatine is employed, will be applicable to many decorative purposes. Bookbinders, paper-stainers, and printers will find them useful. They may also, it is said, be used to color confectionery and soaps. Before they are used for confectionery, however, it will be well to make sure that no arsenic is present.

2559. Injurious Effects of Impure Alcohol upon Aniline Colors. Dr. Tillmanns has examined several varieties of alcohol, and tested the effects upon aniline colors. The most sensitive among these, for impure alcohol, is aniline purple (phenyl-rosaniline). It appears that empyreumatic substances, aldehyde, the peculiar fusel oils due to the substances used in the manufacture of the alcohol, affect the aniline colors when dissolved in such alcohols and boiled therewith. The best test for the purity of an alcohol is to dissolve in it 1 per cent. of perfectly pure caustic potassa, and to heat the solution; it should only acquire a bright yellow color. Another test is to dissolve 1 part of the aniline purple alluded to in 50 parts of the alcohol to be tested, and to heat the fluid for some time. If, after half an hour's heating, no change is observed, the quality of the alcohol is good; but if the latter is not pure enough, the mixture soon becomes turbid, and assumes a red color. Another test is to make two solutions of the color of the same strength (1 in 50), one with alcohol of known purity, and the other with the suspected alcohol, and then compare the intensity and shade of the solutions. Aldehyde is often present in alcohol, especially if it has been purified by means of charcoal.

2560. To Test the Quality of Aniline Colors. A good and practical way of testing the merits of aniline colors is to have, and keep on hand, a standard and measure of comparison, a sample whose value and coloring power has been ascertained by actual practice. If a new supply of dye stuff is to be tested, weigh out equal quantities of the standard coloring matter and of the one to be tested (say 10 to 30 grains); dissolve them, using the same quantity of alcohol and water, in vessels of as nearly as possible equal size; introduce in each an equal quantity of white wool; place them on a water bath; raise the temperature gradually, and after sufficient time has elapsed, take the two pieces out, dry them carefully, and compare them. That which has been dyed with the best dye, will, of course, show the fullest, brightest, and clearest color. Instead of testing on skeins of wool, Mr. Shuttleworth recommends small squares of white merino or cashmere, as affording a more even surface, and a greater mass of color. A known weight of the dye should be dissolved in alcohol and added to the bath of warm water, with the necessary mordants. A square of cloth of known weight —say 10 grains—is immersed in the bath, and, after a stated time, removed. The strength and shade of the color can thus be compared with previous samples, dyed under like conditions. It is a good plan to paste these squares, by one edge, in a blank book, noting anything worthy of remark on the margin. The colors are thus preserved from the action of the light, and will be found very useful for reference.

2561. Test for Sugar in Aniline Dyes. Aniline blue and aniline green have been found adulterated with a considerable quantity of sugar. Mr. Joly, of Brussels, has also found this to be the case with red aniline colors, such as fuchsine, rubine, &c., the adulteration amounting in some cases to as much as 50 per cent. The amount of sugar present can be ascertained by treating a sample of the suspected dye with absolute alcohol; or, still better, with a mixture of alcohol and ether; the sugar will remain undissolved.

2562. To Remove Sugar from Aniline Dyes. If it be found by the test given in No. 2561, that an aniline color has been adulterated with sugar, this may be removed by repeatedly washing the color with cold water, which will dissolve the sugar.

2563. General Directions for the Use of Aniline Dyes. It is impossible to use any dye, successfully, without due regard to cleanliness. This is, perhaps, more particularly the case with the anilines. The slightest trace of a foreign substance will often materially alter the shade. Earthen or enameled vessels should be used whenever practicable. Iron is generally to be avoided, if for no other reason than that it is difficult to say when it is really clean. Woolen and silken goods, before being dyed, should be thoroughly washed in soap and water, and then carefully rinsed in clean rain water. Cotton requires a previous mordanting before it can be dyed with anilines, as vegetable fibre possesses no affinity for the colors. The preparation generally consists in treatment by sumac, or stannate of soda, and subsequently by sulphuric acid; special directions will be given in those cases requiring particular treatment. Old fabrics which were dyed before, may be freed from color by previous boiling for an hour in strong soapsuds. The spirit used should be pure, and especially free from aldehyde; methyl spirit does not appear to injure some of the dyes. Spirit containing shellac turns roseine of a bluish color.

2564. To Distinguish Aniline from Other Dyes. Aniline colors, for dyeing purposes, are now used to such an extent throughout the country as almost to exclude all others, on account of their brilliancy and cheapness. They are, however, liable to lose in appearance by bright sunlight, and in lustre by the artificial light of gas or candles. It is, therefore, desirable to have a ready means by which they can be recognized. This is all the more necessary, as arsenic acid is generally employed in their preparation; and a cloth that has been dyed with an aniline color containing it may have absorbed a considerable quantity of that dangerous article. The readiest way for its detection is to boil the flannel, or whatever other cloth it may be, with a solution of caustic soda or potassa, and, after filtering the fluid from the residue, neutralizing it with hydrochloric acid. If the cloth has been dyed with an aniline color, the fluid will show a coloration. Most of the aniline dyes may also be extracted by boiling alcohol, which process, perhaps, can be performed in less time than the other.

2565. To Remove Aniline Colors. There are various ways proposed to remove aniline colors, the following being the simplest and most practical. Goods dyed with aniline colors may easily be rendered white by the use of zinc gray; the metallic zinc contained in this powder reduces the colors, forming soluble colorless products. To apply the principle, triturate 100 grains zinc gray with 50 grains mucilage marking 20° Baumé, until the mixture is homogeneous; incorporate with this 20 grains of a solution of hyposulphite of soda marking 20° Baumé, apply this mixture directly to the goods, let it dry and vaporize. After this operation it is best to wash the goods with water slightly acidulated with hydrochloric acid. Cotton goods may be bleached by chlorine or bleaching liquor, but this is not applicable to other than cotton fabrics.

Another simple method consists in digesting the fabrics for a sufficient length of time in 90 per cent. alcohol, which usually completes the decolorization in a short space of time. The same alcohol can be used several times in succession, and can afterward be purified by rectification or redistillation, so as to involve but little loss. The work is best done in a well-covered copper kettle, which is to be set in boiling water. A little hydrochloric acid may be added if the articles are not too delicate, thereby increasing the solubility of the aniline colors.

If all other methods fail, cyanide of potassium is absolutely certain. A stone vessel is to be selected, in which a small quantity of cyanide of potassium is to be introduced, and hot water poured upon it, so as to make a solution of ½° to 1° Baumé. The whole is to be stirred well with a long and strong glass rod, and the operation conducted in the open air, so that no harm may result from the condensation of the vapor. The fabric in question, previously well cleaned, is now placed in the vessel, and pushed under the liquid with the glass rod, and the top of the vessel laid on. It is advisable to keep the solution warm, by immersing the stone vessel in a wooden tub properly supplied with steam or hot water. After a short time the lid should be removed by taking it off at the end of a long handle, allowing the vapors to pass off before the operator comes near. By means of the glass rod the cloth is to be lifted, and if not entirely white, is to be replaced and the process continued still longer. When finished the cloth is to be transferred by means of the glass rod to a large vessel containing hot water, and stirred around for a time, then removed and rinsed off. The solution of the cyanide of potassium can be used several times without losing its power. Cyanide of potassium is a deadly poison; contact with any sore or cut is extremely dangerous, and inhaling its vapor is sudden death.

2566. To Remove Stains of Aniline from the Hands. The best way to remove such stains from the hands is to either wash them with strong alcohol, or what perhaps is more effectual, to wash them with a little bleaching powder, and finally with alcohol.

2567. Phosphate of Lime as a Mordant. A rather thick syrupy solution of phosphate of lime (bone-ash) in hydrochloric acid having been recently recommended as a mordant to be used after a previous sumaching of the goods, Dr. Reimann states that, according to his researches, the phosphate of lime solution is altogether superfluous for aniline dyes, since a sumaching with 4 pounds sumach to 20 pounds cotton is of itself a sufficient mordanting to fix aniline colors excellently. The application of the phosphate of lime solution as a mordant for cochineal colors upon cotton he also considers as quite useless.

2568. New Mordant Applicable to Aniline Colors. For this purpose the oxide of zinc, in accordance with a patent taken out in France by MM. Biot and Thisau, may be used for mordanting aniline blue upon cotton, or the iodine green upon wool. The mordanting is effected by simply immersing the goods for some hours in a bath of cold water, in which chloride or acetate of zinc has been dissolved until the solution shows 2° Baumé; for the wool the mordanting bath should be at a boiling heat, and the goods should also be placed in a warm bath of tannin 90° Fahr. for half an hour. In dyeing, a hot solution of the color must be used, to which should be added, in the case of the cotton, some chloride of zinc, and, in the case of the wool, a certain amount of tannin solution.

2569. To Dye Aniline Opal Blue on Cotton. To mordant the aniline color known as opal blue upon cotton it is recommended to rinse the goods, after bleaching, in a dilute solution of soda crystals, to neutralize the acid of bleaching, then to pass them into a hot bath of soap, in which oil exists in emulsion in these proportions: Water, 100 liters (211 pints); soap, 8 kilos (21½ pounds troy); oil, 2 kilos (5¼ pounds troy). Wring them out, dry, and pass them into a solution of acetate of alumina of about 4° or 5° Baumé, wring out, dry, and rinse in hot water. Finally dye in a solution of opal blue to which acetic acid has been added. The temperature of the dye bath should be 75° to 90° Fahr. Rinse and dry.

2570. Difficulty in Dyeing Cotton with Aniline. This difficulty consists in the irregularity of intensity of color when the aniline colors are applied. This effect is attributed to the unequal oxidation of the tin salts applied before dipping the goods into the dye bath; in using these colors, avoid the use of the tin salts, which have little or no beneficial effect on the results in any case; and dip the goods into the dye bath, after treating with infusion of nut-galls or sumach. If tin must be used, the best salt of that metal is the bichloride.

2571. Aniline Black. When a salt of aniline in solution is exposed to the action of certain oxydizers, as salts of copper, chlorate, and bichromate of potassa, it yields a black dye, of such depth that ordinary gall or madder blacks appear gray or green in comparison. The fastness of this color, its resistance to the action of acids, alkalies, soaps, and sunlight, render it of great importance to manufacturers, and make it one of the great achievements of late years.

2572. Aniline Black for Dyeing. According to Mr. Köchlin, aniline black is produced as follows: Water, 20 to 30 parts; chlorate of potassa, 1 part; sal ammoniac, 1 part; chloride of copper, 1 part; aniline, hydrochloric acid, of each 1 part, previously mixed together. Several other formulæ for producing aniline blacks have been devised for dyeing purposes. It is essential in each of them, and always, that the preparation shall be acid, and the more acid it is, the more rapid is the production of the blacks. The action, of course, if it be excessive, will be likely to injure the fibre of the fabric.

2573. Aniline Black on Wool. For 2 pounds of wool a bath is prepared of 20 quarts water, 3 ounces permanganate of potassa, 4½ ounces sulphate of magnesia. The use of sulphate of magnesia has for its object, to prevent the formation of caustic alkali, and has already been proposed by Tessié du Mothay. The wool is impregnated with this solution, and left in it until the fluid has become colorless, or nearly so, whereby it is colored dark-brown and covered with brown oxide of manganese. This process takes place easily in the cold, but it is best to dissolve the permanganate in hot water. The wool is now pressed out, and, without washing, conveyed into a bath of 12 ounces commercial aniline oil, 21 ounces commercial hydrochloric acid, and 8 quarts water, where it is moved about in the cold; it attains here directly a dark green-black color. It is pressed out again, washed in water containing a little soda, and treated with a weak solution of ¾ ounce bichromate of potassa in 10 quarts water. The color becomes now dark black, when the wool is washed with water and dried.

2574. Persoz's Aniline Black for Wool or Silk. Steep the silk or wool for 1 hour at a boiling heat, in a bath consisting of 5 grammes (77 grains) bichromate of potassa, 3 grammes (46 grains) sulphate of copper, and 2 grammes (31 grains) oil of vitriol, for each litre ($2\frac{1}{10}$ pints) of water used. It is then thoroughly washed, and afterward passed through a solution of oxalate of aniline marking 1° to 2° Baumé, in which it at once assumes a black color. In case the fabric contains a vegetable fibre, the first bath must be replaced by a series of baths resulting in chromate of lead. This is effected by successive passages through a solution of nitrate or acetate of lead, then through a hot one of sulphate of soda; and lastly through a cold bath of from 5 to 20 grammes (77 to 300 grains) bichromate of potash to the litre ($2\frac{1}{10}$ pints) of water.

2575. To Prepare Magenta for Dyeing. This color, which is also called rosein, fuchsine, and aniline red, is the best known of the series. It is better adapted for the preparation of a liquid dye than any other. In the hands of the amateur it can be used with economy, and the results obtained are generally satisfactory. It is readily soluble in alcohol, and to some extent in water. The latter property is taken advantage of by dyers, the dye bath being prepared directly from the crystals. It is, however, preferable to use alcohol for dissolving the color, as the solubility in water is not always the same with different samples. To 1 pound of the crystals add 2½ gallons of spirit .8200 specific gravity. The solution may be conveniently made in an ordinary 5-gallon tin. Agitate frequently, and add 2½ gallons of hot water. This product will be suitable for sale as a liquid dye, but for dyers' use, where a large quantity of water is admissible, 1½ gallons of spirit will be found sufficient. It is sometimes necessary to filter before using.

2576. To Dye Silk or Wool Magenta. Sufficient water to cover, without difficulty, the fabric to be dyed, is brought to a temperature of about 170° Fahr.; a sufficient quantity of the dye is added, and followed by the immersion of the goods, which should be moved about to prevent streaks. About half an hour's immersion is sufficient. Half an ounce of the crystals should give a fair shade to 10 pounds of wool. A bath of soap-suds is sometimes employed instead of water, and by the use of alkali, brighter, but perhaps less permanent colors are produced. Acids render the shade dull and bluish.

2577. To Dye Cotton Magenta. Place the cotton in a bath of sumach (1 pound sumach to 10 pounds cotton) for 2 hours. Wring out, and dye in the same manner as wool. (*See previous receipt.*) A brighter shade is given by dissolving ¼ ounce soap in hot water, letting the solution cool to 90°, adding 2½ ounces olive oil, and mixing with tepid water. In this 5 pounds of cotton may be worked for about 5 minutes. A bath containing ½ pound sumach and 1 ounce tin crystals is next prepared, through which the cotton should be passed, wrung out, and finally dyed in a bath of magenta and pure water.

2578. Aniline Cerise and Safranine. These colors resemble magenta in appearance, and appear to be varieties of that substance. They are readily soluble in alcohol, and more or less so in water. The colors produced are similar to those obtained from safflower, but possess greater vivacity and permanence. The shades are exceedingly delicate and beautiful, inclining to pink with a shade of yellow. The dye bath is prepared, and the fabric dyed, in the same manner as magenta. (*See Nos. 2575, &c.*)

2579. To Dye Aniline Yellow. This color is slightly soluble in water, and for dyers' use may be used directly for the preparation of the dye bath. It is, however, preferably prepared in a liquid state, by dissolving 1 pound of dye in 2 gallons of alcohol. (*See No. 2575.*) Without any addition to the dye bath very good yellows may be produced, but the color is much improved and brightened by a trace of sulphuric acid. The temperature of the bath should be under 200° Fahr.

2580. Schiff's Aniline Yellow. This matter, according to Schiff, is easily prepared by means of hydrated antimonic or stannic acid. Stannate of soda or other alkaline antimoniate or stannate is to be pounded with half its weight of aniline to a clear pulpy consistence, then hydrochloric acid is added till the acid reaction takes place. It is then shaken up, and the scarlet color removed by etherized alcohol, the mass being, of course, previously dried. After proper purification it is allowed to evaporate spontaneously, and in this way are formed flakes of a hydrochlorate, having for base a red coloring matter, which must not be confounded with rosaniline. When this hydrochlorate is decomposed by alkalies, deep yellow flakes are deposited, which again become red in presence of acids. By impregnating silk or wool with this red color, and then passing it into a hot solution of carbonate of soda, a beautiful yellow tint is developed, similar to the yellow of picric acid, and which M. Schiff claims to possess considerable stability.

2581. To Dye with Aniline Crimson. A solid dye, belonging to the same series as the preceding, is sold as crimson, but it does not appear to differ very materially from magenta, giving shades with a trifle less blue. It is applied in the same manner as magenta. (*See Nos. 2575, &c.*) Much better colors are obtained by the use of aniline yellow (*see No. 2579*) and magenta. The former may be applied in the manner indicated for that color, and the fabric so dyed must be passed through a bath of magenta until the required shade is produced. By mixing the liquid yellow and magenta dyes in a bath of soap-suds, nearly every shade from magenta to orange may be obtained. This will be found a satisfactory method for amateurs.

2582. To Prepare Aniline Scarlet Dye. To produce this color, aniline scarlet dye may be used. Neither this nor coralline is adapted for amateur use, as great exactness is required in compounding the dye bath. For the use of amateurs, aniline yellow and magenta, as indicated for crimson (*see No. 2581*) is recommended. To produce scarlet the yellow should predominate, or the bath may be rendered slightly sour by sulphuric acid. Aniline scarlet dissolves easily in water, and the bath may be made directly from the solid substance. A liquid dye may be made, if desired, by dissolving 1 pound scarlet in 4 gallons water and 1 gallon alcohol.

2583. To Dye with Aniline Scarlet. Add to the bath containing the dye, an excess of alum and cream of tartar; neutralize carefully by carbonate of soda—the exact point may be known by the liquid changing from a yellowish to a pinkish red.

2584. To Dye Aniline Scarlet. For every 40 pounds of goods, dissolve 5 pounds white vitriol (sulphate of zinc) at 180° Fahr., place the goods into this bath for 10 minutes, then add the color, prepared by boiling for a few minutes, 1 pound aniline scarlet in 3 gallons water, stirring the same continually. This solution has to be filtered before being added to the bath. The goods remain in the latter for 15 minutes, when they have become browned, and must be boiled for another half hour in the same bath, after the addition of sal ammoniac. The more of this is added the redder the shade will become.

2585. To Prepare Coralline Dye. Dissolve 1 pound coralline in 1½ gallons alcohol specific gravity .8200, by the aid of heat; mix the solution with 7½ gallons boiling water, and re-dissolve the precipitated dye by the cautious addition of water of ammonia.

2586. To Dye with Coralline. Add the color prepared as in No. 2585, to the dye bath, and neutralize with acetic acid. The exact point is indicated by the pink color of the solution changing to an orange red. Immerse the goods, and, when the required color is obtained, remove and wash in a bath of soap-suds.

2587. Water-Glass as a Solvent of Coralline. Dissolve coralline in a boiling mixture of 1 part concentrated water-glass (silicate of soda or potassa of the consistency of a thick syrup), and 4 parts water, and, after cooling, apply this solution as a paint for wood (white woods containing little or no tannic acid are preferable), paper, toys, artificial flower tissues, &c., to all of which materials this solution of coralline imparts a beautiful carmine red tint.

2588. Preparation of Innoxious Coralline. M. Guyot states that coralline is frequently poisonous, because the rosolic acid, used to obtain it, contains phenol (carbolic acid), and this dangerous quality in the product can only be avoided by using the exact proportions necessary, in manufacturing the compounds.

2589. To Prepare Aniline Brown for Dyeing. This color may be used as a liquid dye, and for this purpose 1 pound of the brown may be dissolved in 2 gallons of spirit specific gravity .8200.

2590. To Dye with Aniline Brown. Add a sufficient quantity of the dye, prepared according to the previous receipt, to the dye bath, and immerse the fabric. Wool possesses a very strong affinity for this color, and no mordant is required. A snuff brown, more or less deep, is produced.

2591. To Prepare Bismarck Brown for Dyeing. Mix together 1 pound Bismarck, 5 pounds water, and ¾ pound sulphuric acid. This paste dissolves easily in hot water and may be used directly for dyeing. A liquid dye may be prepared by making the bulk of the above mixture to 2 gallons with alcohol.

2592. To Dye Wool Bismarck Brown. Render the bath, prepared as in No. 2591, sour with sulphuric acid; add a quantity of sulphate of soda, immerse the wool, and add the color by small portions, keeping the temperature under 212° Fahr. Very interesting shades may be developed by combining the color with indigo paste or picric acid. (*See No.* 2601.)

2593. To Dye Cotton Bismarck Brown. Cotton requires mordanting with sumach and acetate of alumina, and is dyed in a bath under 100° Fahr., prepared according to No. 2591. By the use of bichromate of potash redder shades may be obtained. The usual color inclines to cinnamon.

2594. To Dye with Vesuvine. This aniline color is prepared and used in the same manner as magenta. (*See No.* 2575, *etc.*)

2595. To Dye with Aurine. Dissolve 1 pound aurine in 2 gallons alcohol specific gravity .8200. This color is used principally for silk. Dye in a bath containing a trace of sulphuric acid. By combining with magenta (*see No.* 2575), very bright colors are produced.

2596. To Dye with Palatine Orange. The palatine orange dye is prepared in a similar manner to magenta. (*See No.* 2575.) Render the bath slightly acid by bichloride of tin, and dye at the boiling point. A very fast, but not very brilliant orange is produced. The color may be combined with magenta or indigo paste.

2597. To Dye with Phosphine. Phosphine is treated in the same way as palatine, omitting the sulphuric acid, and substituting a trace of carbonate of soda; or use a soap bath.

2598. To Dye Silk with Aniline Green. Iodine green, or night green, dissolves easily in warm water. For a liquid dye, 1 pound may be dissolved in 1 gallon alcohol, and mixed with 2 gallons of water containing 1 ounce sulphuric acid. This color is almost always a failure in the hands of the amateur, and is not recommended. For silk, no addition to the dye bath is required, the temperature being kept under 180° Fahr.

2599. To Dye Wool with Aniline Green. For wool, prepare two baths, one containing the dissolved dye and a quantity of carbonate of soda, or borax. In this the wool is placed, and the temperature raised to 212° Fahr. A grayish green shade is produced, which must be brightened and fixed in a second bath of water at 100° Fahr., to which some acetic acid has been added. Cotton requires preparation by sumach. (*See No.* 2577.)

2600. To Dye with Iodine Green. Mix 3 pounds of iodine green paste well with about 2¼ pounds of cold water; then add successively, 1 pound acetic acid 8° Baumé, 80 pounds water of a temperature of 140° Fahr, and 2 pounds liquor ammonia, stirring the mixture well all the while, and filtering it before use. Bring the dye bath to the boiling point; put in as much of the solution as is necessary for the shade required, and dye for half an hour, letting the bath cool off in the meantime. Then have a second water bath of 140° Fahr. ready, prepared as follows, viz.: For every 20 pounds of wool, add ½ pound sulphuric acid 66° Baumé, and ½ pound perchloride of tin crystals, the latter previously dissolved in an equal quantity of water. Take the goods from the first bath, without washing, into the second bath, turn them in it for 15 minutes, and the green will develop vividly. For yellowish tints, shade off with picric acid (*see No.* 2601), which must be added to the second bath and dyed quickly. By this method, 1 pound of iodine green paste will dye 12 pounds of wool a medium shade. Preserve the first bath, inasmuch as one-third of the dye remains in it, which circumstance is important in renewing the bath, which will, consequently, require one-third less dye-stuff when making it for the second lot.

2601. To Dye with Picric Acid. Dissolve 1 pound picric acid in 1 gallon of alcohol specific gravity .8200. The dye bath requires no addition, or special precaution. This color is used to produce shades of lemon and canary which cannot be attained by the aniline yellow or phosphine. Its chief use is for dyeing green. For this purpose pass the fabric through a bath containing sulphuric acid and alum, adding, after thorough immersion, a sufficient quantity of solution of picric acid and indigo extract (*see No.* 99) to produce the desired shade.

2602. To Dye with Aniline Blue. To 100 pounds of fabric dissolve 1½ pounds of aniline blue in 3 quarts hot alcohol; strain through a filter, and add it to a bath of 130° Fahr., also 10 pounds Glauber's salts and 5 pounds acetic acid. Enter the goods, and handle them well for 20 minutes; next heat it slowly to 200° Fahr.; then add 5 pounds sulphuric acid diluted with water. Let the whole boil 20 minutes longer, then rinse and dry. If the aniline be added in two or three proportions during the process of coloring, it will facilitate the evenness of the color. The blue, or red shade of blue, is governed by the kind of aniline used, as there is a variety in the market. Hard and close-wove fabrics, such as braid, ought to be prepared in a boiling solution of 10 pounds sulphuric acid and 2 pounds tartaric acid before coloring with the aniline, as this will make the fabric more susceptible to the color. Blues soluble in water color more easily than those which have to be dissolved in alcohol.

2603. To Dye Silk or Wool with Aniline Blue. In this manner are used the varieties of aniline blues known as *Bleu de Lyon*, *Pure Blue*, *Red Blue*, and all others soluble in alcohol. Into a stone jar fitted with a cover, through which a hole is made to admit a stick for stirring, put 1 pound of the dye, 5 gallons alcohol specific gravity .8200, and 2 ounces sulphuric acid; apply the heat of a water bath and stir frequently. After allowing the mixture to cool, filter, and treat any undissolved residue with fresh alcohol until complete solution is effected. From 5 to 8 gallons will be required. The dye bath for wool should be rendered sour by sulphuric acid. Tin crystals may be used, in quantity equal to about $\frac{1}{75}$ the weight of the wool, to improve the vivacity of the shade. The bath should be brought to the boiling point. For silk, prepare a soap bath, add the color, and put in the goods. When dyed sufficiently, pass through a bath acidulated with sulphuric acid.

2604. To Dye Cotton with Aniline Blue. Cotton is prepared as for magenta (*see No.* 2577), and dyed in an acid bath as for wool. (*See No.* 2603.)

2605. To Dye with Aniline Water-Blue. This color is quite soluble in water, and will answer well for preparing a liquid dye; 1 pound may be dissolved in a mixture of 1 gallon alcohol and 4 gallons water. Dyers dissolve the powder in the dye bath. The dye is used in the same way as Bleu de Lyon. (*See No.* 2603.)

2606. To Dye with Alkali Blue and Nicholson's Blue. Dissolve 1 pound of the dye in 10 gallons boiling water. Add this, by small portions, to the dye bath, which should be rendered alkaline by borax. The fabric should be well worked about between each addition of the color; the temperature must be kept under 212° Fahr. If the right proportion of borax has been used the goods will show but little color when removed from the bath. To develop this, wash with water and pass through a bath containing sulphuric acid.

2607. To Dye with Aniline Violet and Purple. The various aniline purples known as *Parme*, *Violet de Fuchsin*, *Victoria Violet*, and *Amaranth*, are used in the same manner as Bleu de Lyon (*see No.* 2603), omitting the sulphuric acid. Acidulate the bath by sulphuric acid, or use sulphate of soda; both these substances render the shade bluish. Dye at 212°. To give a fair middle shade to 10 pounds of wool, a quantity of solution equal to ½ to ¾ ounce of the solid dye will be required. The color of the dyed fabric is improved by washing in soap and water, and then passing through a bath soured by sulphuric acid. According to Mr. Hirsch, cotton is treated as follows: Prepare the goods for fuchsine, and turn them over a few times in a tepid solution of 2½ ounces crystallized perchloride of tin, for every 10 pounds of goods. Remove the latter, add as much violet solution as the shade requires, dye for a quarter of an hour, wring well, and dry. Washing in a solution of alum and starch will render the color more solid.

2608. To Dye with Hoffman's Purple. The dye is prepared as other purples. (*See No.* 2607.) Some authorities maintain that this color does not require the addition of acid to the dye bath, but the color is apt to rub off when dyed in this manner. A trace of tartar, or of tartaric, oxalic, or any vegetable acid may be used with advantage; but mineral acids are to be particularly avoided. The bath should be kept at a boiling temperature.

2609. To Dye Woolens Blue with Aniline. To the water in the vat sulphuric acid is added in sufficient quantity to cause it to taste as acid as vinegar; it is then brought to boiling, and kept so for 10 minutes; some blue aniline liquor is then added with stirring; the goods are submerged, and kept under while boiling until the water has lost its color; after which they are removed, fresh liquor is added, and the process continued until the desired color has been given, the water being kept constantly at a boil. (*See No.* 333.)

2610. To Dye Silk Blue with Aniline. Silk is steeped first for an hour in lukewarm water, acidulated with sulphuric acid, as for woolens in the last receipt, and the color must be added in 4 to 5 small portions, raising the temperature gradually to boiling, and continuing it at that, when a good color has been obtained, for some 5 to 10 minutes. The old bath is then replaced by fresh water, which is acidified with sulphuric acid, and in which the silk is boiled for 10 minutes; after which it is thoroughly washed in water and then in suds, afterwards again in water, then once more drawn through acidulated water, and lastly through water alone. (*See No.* 333.)

2611. To Dye Silks or Woolens Violet or Purple with Aniline. Violets and purples are produced on wool in the same manner as the blue; on silk the same method is used likewise, but the water must only be heated short of boiling. (*See Nos.* 315 *and* 316.)

2612. Jacobson's Method of Combining Fat and Oil with Aniline Red. The following process is given for this purpose by Dr. E. Jacobson. First separate rosaniline from commercial fuchsine by heating with soda or digestion with ammonia; wash and dry it. An oleate or stearate of rosaniline is next obtained by adding the rosaniline to oleic acid or melted stearic acid as long as it will dissolve, or by putting them together in equivalent proportions. An excess of oleic acid must be avoided when the compound is required for a varnish, as it delays the drying. Oleate or stearate of rosaniline easily dissolves in fats or oils, and colors these an intense red. If it is wanted for a linseed oil varnish, the linseed oil must be free from lead. The compound must be kept from the fire, or it soon turns blue, probably by the reducing action of the fatty acids. The best red color is obtained in linseed oil varnish. Stearine with oleate or stearate of rosaniline appears a bluish red. Paraffine appears to act as a reducing agent with the compounds of fatty acids and aniline, and changes to a dirty violet color; the mixture then is inapplicable to the coloring of paraffine or stearine candles. The oleate or stearate of rosaniline is a good coloring agent for hair oil or pomatum, but, from the instability of the color, seems inapplicable for oil painting.

2613. Dyeing with Fuchsine on Wool or Silk. Fuchsine (the crystals of acetate of rosaniline), or the solution, is mixed with cold water for silk, or in water of 130° to 140° Fahr. for wool, which temperature is kept up. For silk, a few drops of acetic acid are also added. The strength of the dye regulates the quantity which is required. The goods are merely immersed in the bath until they have taken up sufficient of the color; it is not always advisable to work them about while in the bath.

Liquid Colors for Various Purposes.

These receipts include the preparation and appliance of such liquid colors as are used to tinge or impart color to matter generally. Their particular uses and appliances are specified in the receipt given for each preparation. In addition to those here given, a number of other receipts for coloring matter have been necessarily included under the respective headings of the special objects for which they are used, and will be readily found by consulting the index.

2615. Soluble Prussian Blue. Add a solution of protosulphate of iron to a solution of prussiate of potash, and expose the precipitate to the air till it becomes blue, and wash it till the soluble salts are washed away. By continuing the washing, the blue itself dissolves, forming a deep blue solution, which may be evaporated without decomposition. Or, add a solution of persulphate of iron to a solution of ferroprussiate of potash, keeping the latter in excess; wash the precipitate until it begins to dissolve, and dry it. (*See No.* 2488 *for another method.*)

2616. Chemique, or Chemic Blue. Sulphate of Indigo. To 7 or 8 parts of oil of vitriol, in a glass or earthen vessel, placed in cold water, add gradually 1 part of fine indigo in powder, stirring the mixture at each addition with a glass rod or piece of tobacco-pipe. Cover the vessel for 24 hours, then dilute with an equal weight of water. Sometimes it is sold without diluting. The German *fuming acid* answers best, 4 or 5 parts of it being sufficient for 1 of indigo. For dyeing silk, &c., carbonate of potash, soda, or ammonia, is added, to neutralize the acid, taking care not to add it in excess. (*See Nos.* 98 *and* 4791.)

2617. Liefchild's Patent Blue for Linen. Mix 4 parts Chinese blue, 1 of Turnbull's blue, and 1 of oxalic acid; gradually add boiling water until the whole is dissolved, and lastly 4 parts of sulphate of indigo. The latter is made with 1 part indigo, and 4 sulphuric acid, neutralized with carbonate of ammonia.

2618. Blue for Linen. The ordinary kinds of cake blue consist of indigo and starch.

2619. Solvents for Indigo. Indigo will dissolve in Venice turpentine heated to its boiling point, or in boiling paraffine, with the same blue color as the solution of sulphuric acid; and in petroleum it forms a carmine solution, while in spermaceti it produces a carmine-violet, and in stearic acid a blue color.

2620. Bluing for Clothes. Take 1 ounce of soft Prussian blue, powder it and put in a bottle with 1 quart of clear rain water, and add ¼ ounce of oxalic acid. A tea-spoonful is sufficient for a large washing.

2621. Purified Annotto. To a boiling solution of pearlash add as much annotto as it will dissolve. When cold, decant the clear solution, and neutralize with diluted sulphuric acid, avoiding any excess. Wash the precipitate with a little cold water, and dry it.

2622. Solution of Annotto. Boil equal weights of annotto and pearlash with water, and dilute to the required color.

2623. Cochineal Coloring. Take 1 ounce each powered cochineal, carbonate of potash, bitartrate of potash, and alum; boil these in a glazed vessel with 7 ounces water and 1 ounce spirit of wine, until effervescence ceases (about 10 minutes). In this liquid dissolve an equal weight of refined sugar by means of sufficient heat, and set aside for use. This coloring remains bright for any length of time, does not throw down any precipitate, and is almost unalterable by contact with either acids or alkalies, which is no small advantage. Dickson's coloring has some disadvantages in the large quantity of spirit and the delicacy of the ammonia tint. The first would have a tendency to cause a cloudy appearance in bright jellies and other preparations containing gelatine, and the ammonia color would be liable to be completely changed when brought in contact with lemon juice, baked pears, and other acids met with in the many culinary purposes for which the article is largely used.

2624. Dickson's Cochineal Coloring. Mix together 2 ounces spirit of wine and 6 ounces water. In 3 ounces of this mixture infuse 1 ounce powdered cochineal for 15 minutes, in a flask heated to nearly boiling point. Pour the infusion into another vessel, and repeat the process with 3 ounces more of the mixed spirit and water; and a third time, with the remaining 2 ounces. Let the liquid stand till cold, when some fatty matter will rise to the surface; filter, adding spirit and water, up to eight fluid ounces. Lastly, add sufficient strong water of ammonia to change the infusion to the desired tint. The coloring is thus prepared without carbonate of potash, alum, etc., and is free from the objections that attach to the coloring obtained by the aid of those substances. (*See last receipt.*) These objections are:—1st, the coloring matter is thrown down as a lake, and after some time forms a layer at the bottom of the containing vessel, requiring the addition of ammonia to re-dissolve and keep it in solution; and—2d, it does not keep well. On the other hand, the advantages of Dickson's preparation are:—1st, the coloring-matter remains in solution, and—2d, it keeps well, and has no unpleasant odor.

2625. Cochineal Coloring. Macerate 1 ounce best carmine in 6 ounces strong solution of ammonia, until it is dissolved. Heat *gently* to drive off excess of ammonia, taking care not to carry it too far, so as to precipitate the carmine. Put into a quart wine bottle, and add 4 ounces rectified spirit and 3 pounds white sugar. Fill up with warm water, and shake until the sugar is dissolved. This is a splendid coloring.

2626. Black Lustre Color for Paper, Cloth, or Wood. Dr. Kielmeyer gives a receipt which is adapted for either paper, cloth, or porous wood. He states that it stands well, is very supple, and has no tendency to get sticky. To prepare it, boil together 8 pounds glue, previously dissolved in 16 pounds water; 1 pound potato starch, dissolved in 5¼ pounds water; 5¼ pounds campeachy extract of 6° Baumé, 1 pound 2 ounces green vitriol, and 8¾ pounds brown glycerine. When thoroughly mixed, remove the pot from the fire, and continue to stir until the liquid is cold. If the paint be desired thicker or thinner, the amount of starch and glue must be varied as well as the other materials, or the lustre will suffer.

2627. Black Produced by the Mixture of Colorless Liquids. One of the most interesting phenomena in the operations of chemistry occurs in the decomposition of sulphate of iron by gallic acid. Into a wine-glass, containing the infusion of galls, pour a solution of the sulphate of iron. The gallic acid, from its superior elective affinity to the iron, detaches it from its former combination with the sulphuric acid, and in a short time these two fluids, previously colorless, become intensely black. To make this black fluid into ink, nothing but a little gum is required, to retard the precipitation of the coloring matter.

2628. To Make Liquid Blue. Put into a bottle 1 ounce pure Prussian blue, in fine powder, and pour upon it 2 ounces concentrated hydrochloric acid. Effervescence ensues, and the mixture soon assumes the consistence of a thin paste. Leave it for 24 hours, and then dilute with 8 or 9 ounces water, and bottle it. The whole may be further diluted with a quart of water and still retain a sufficiently dark color for washing muslins, etc. The common blue writing fluid is thus prepared.

2629. Carmine Purple. The dye recently invented, and known as carmine purple, is obtained by the solution of uric acid in nitric acid, care being taken to prevent boiling over and too great an increase of temperature. The mixture should remain standing quietly for some days, after which a thick, pasty, or doughy substance is obtained, which is to be treated with warm water, filtered, and the residuum again treated with warm water. The filtered liquid possesses a reddish or yellowish color, resulting from the organic substances decomposed by the nitric acid. It is next to be evaporated in a large enameled iron vessel, but not heated to the boiling point, which would destroy the murexide (carmine purple) produced. After the liquid has been evaporated to a syrupy consistency, and has assumed a beautiful brownish-red or violet color, it is to be allowed to cool. The entire quantity of the liquid should never be evaporated at one time, nor heated to the boiling point.

2630. To Color with Alkanet Root. Anchusa Tinctoria gives a fine red tinge to oils, fats, wax, turpentine, spirits, essences, etc., and is used to color hair oil, pomatums, ointments, varnishes, etc. The spirituous solution stains marble of a deep red; wax tinged with alkanet and applied to warm marble, leaves a fresh color.

2631. To Color with Mallow or Malva Flowers. The mallow or malva flower is a native of Europe, growing abundantly on waste grounds and by the waysides. It is also sometimes cultivated in this country. This flower, which gives a beautiful color to water, is used for coloring port and claret wines, and it is considered one of the best articles that can be employed for that purpose. Weigh 2 pounds, and steep the red petals in cold water for 5 or 6 hours. Tartaric acid mixed with the mallow gives a bright red color, and salt of tartar (carbonate of potassa) a deep purple red.

2632. To Purify Caramel. The caramel of commerce is spirit coloring, or a solution of burnt sugar in water. (*See No.* 694.) In this state it is mixed with variable quantities of undecomposed sugar and certain bitter compounds. To render it quite pure, it should be dissolved in water, filtered, and alcohol added until it ceases to produce a precipitate. The caramel is thus thrown down, while the impurities remain in solution. Pure caramel is a black or dark brown powder, soluble in water, to which it gives a rich sepia tint; it is insoluble in alcohol, and incapable of fermentation.

2633. Blue Dye from Molybdenum. According to late experiments by Professor Boettger, based upon some previous researches of Dr. Schönn, if molybdic acid be dissolved to saturation in concentrated sulphuric acid with heat, an uncolored clear fluid is obtained, forming a double acid of sulphuric and molybdic acid. If a little of this double acid be placed in a porcelain dish and heated till it begins to throw off white vapors, and then a certain quantity of absolute alcohol be gradually added, a beautiful blue color is developed, as if by magic, by means of which silk can be dyed without the use of any mordant.

2634. Mordants. Substances employed to fix the coloring matters of dye-stuffs on organic fibres, and to give them brilliancy and permanency. This they effect, either by their strong affinity for the fibre and the dye matter, serving as a bond of union between the two, or by uniting with, and rendering insoluble, the dye contained in the pores of the fibre. The principal mordants are alum, and the oxides of iron or tin. (*See No.* 93.)

2635. To Color Butter. Pure annotto, when properly prepared, is very successfully used for imparting a good color to fall and winter butter. (*See No.* 2621.) Annotto of course adds nothing to the flavor or quality of butter, but as the pure article, when thus employed for coloring, is quite harmless, there can be no serious objection to its use. In coloring butter with annotto it is important that a prime article be used, and to have it prepared so that it shall be free from sediment and adulteration.

2636. To Color Pickles and Sweetmeats Green. A beautiful green color, entirely destitute of any poisonous qualities, may be made by dissolving 5 grains saffron in ¼ ounce distilled water, and in another vessel dissolving 4 grains indigo carmine in ¼ ounce distilled water. After shaking each up thoroughly they are allowed to stand for 24 hours, and on being mixed together at the expiration of that time a fine green solution is obtained, capable of coloring 5 pounds of sugar.

2637. Chameleon Mineral. Mix equal weights of black oxide of manganese and pure potash, and heat them in a crucible. Keep the compound in closely-stoppered bottles. A solution of it in water passes through various shades of color from green to red.

2638. Cadmium Yellow Color for Soap. The chemical works of Schering, in Berlin, have introduced two shades of sulphide of cadmium, a lemon and orange yellow, for the coloring of toilet soap. Of all the agents thus far tried to give a lively yellow color to soap, sulphide of cadmium (cadmium yellow) has proved the most permanent. Age and sunlight do not affect the color, and the quantity required is exceedingly small.

2639. To Color Soap Yellow with Cadmium. The cadmium yellow (*see above*) is rubbed up with oil, and added to the soap under constant stirring. The color is not dissolved in the soap, but suspended in it, and much depends upon careful mixing.

2640. Liquid Colors. The following, when thickened with a little gum, are used as inks for writing, as colors to tint maps, foils, paper, artificial flowers, &c., and to paint on velvet. Some of them are very beautiful. It must be observed, however, that those made with strong spirit do not mix well with gum, unless diluted with water.

2641. Liquid Blue. Dissolve litmus in water, and add ¼ of spirit of wine. Or, dilute Saxon blue or sulphate of indigo with water. If required for delicate work, neutralize the acid with chalk. Or, to an aqueous infusion of litmus add a few drops of vinegar till it turns full blue.

2642. Liquid Purple. Steep litmus in water, and strain. Or, add a little alum to a strained decoction of logwood. Or, add a solution of carmine (red) to a little blue solution of litmus or Saxon blue.

2643. Liquid Green. Dissolve crystallized verdigris in water. Or, dissolve sap green in water, and add a little alum. Or, add a little salt of tartar to a blue or purple solution of litmus, till it turns green. Or, dissolve equal parts of crystallized verdigris and cream of tartar in water, and add a little gum-arabic. Used as an ink for writing.

2644. Liquid Yellow. Dissolve gamboge in water, and add a little gum-arabic and alum. Used for ink, to stain paper, color maps, &c. Or, dissolve gamboge in equal parts of proof spirit and water. Golden colored. Or, steep French berries in hot water, strain, and add a little gum and alum. Or, steep turmeric, round zedoary, gamboge, or annotto, in spirits of wine. Or, dissolve annotto in a weak lye of subcarbonate of soda or potash. The above are used by artificial florists.

2645. Liquid Red. Macerate ground Brazil in vinegar, boil a few minutes, strain, and add a little alum and gum. Or, add vinegar to an infusion of litmus till it turns red. Or, boil or infuse powdered cochineal in water; strain, and add a little alum and gum. Or, dissolve carmine in liquor of ammonia, or in weak carbonate of potash water; the former is superb. (*See No.* 2623, *&c.*)

2646. To Tint Maps or Architects' Plans. Maps, paper, or architects' plans may be tinted with any of the simple liquid colors just mentioned. To prevent the colors sinking and spreading, which they will usually do on common paper, the latter should be wetted 2 or 3 times with a sponge dipped in alum water (3 or 4 ounces to the pint), or a solution of white size; observing to dry it carefully after each coat. This will tend to give lustre and beauty to the colors. The colors themselves should also be thickened with gum. Before varnishing maps after coloring them, 2 or 3 coats of clean size should be applied with a brush.

2647. Sizing for Prints or Engravings to be Colored. Dissolve 4 ounces finest pale glue, and 4 ounces white curd soap, in 3 pints boiling water; add 2 ounces powdered alum. Used for sizing prints and engravings before coloring them.

2648. Druggists' Show Colors. These are bright and perfectly transparent liquid colors, employed by druggists in ornamental bottles for purposes of display, forming an attractive and distinctive ornament of a drug store window. It has for a long time been tried to render the beautiful colors of permanganates more permanent. They are liable to decompose under the influence of light and atmospheric dust, and no way has as yet been discovered to obviate this difficulty. Many druggists have proposed to fill the bottles in their windows with solutions of aniline colors, but even these have to be renewed from time to time. Neutral metallic salts, that have neither tendency to oxydize nor to reduce, are best employed for this purpose. The receipts here given are among the very best and most used for this purpose. The mixtures require careful filtration through powdered glass in a glass funnel. It will be found desirable to make a little more liquid color than is actually required, to replace the loss occasioned by a second filtration (performed in the same manner as the first), which will probably be necessary after exposure for a few weeks to the light: as any addition of water *after filtration*, to make up the deficiency, tends to weaken the color and detract from its brightness. Druggists' show-bottles are now made of colored glass, and filled with pure water. These are just as effective as the white glass bottles filled with colored waters, and obviously involve much less trouble.

2649. Amber. Digest 1 part dragon's blood, coarsely powdered, in 4 parts oil of vitriol; when completely dissolved, dilute with distilled or soft water to the desired shade, and filter. (*See No.* 2648.)

2650. Indigo Blue. Dissolve indigo in sulphuric acid, and dilute with pure water to the required shade of color; filter as directed in No. 2648.

2651. Blue. Dissolve 2 ounces sulphate of copper in ½ ounce oil of vitriol and 1 pint of pure water; filter as in No. 2648.

2652. Prussian Blue. Dissolve pure Prussian blue in slightly diluted oxalic or muriatic (hydrochloric) acid; add water to bring the color to the desired shade, and filter. (*See No.* 2648.)

2653. Pink. To a solution of chloride or nitrate of cobalt in water, add sufficient sesquicarbonate of ammonia to dissolve the precipitate at first formed. Filter as in No. 2648. Or: Wash 1 ounce madder in cold water; digest it, with agitation, for 24 hours in 3 pints water containing 4 ounces sesquicarbonate of ammonia; then dilute with water to the desired shade, and filter as above.

2654. Purple. To an infusion of logwood, add sufficient carbonate of ammonia or of potassa to make the color. Filter as directed in No. 2648. Or: To an infusion of cochineal, add sufficient sulphate of indigo, nearly neutralized with chalk. Filter as above.

2655. Red. Dissolve carmine in aqua ammonia and dilute with water to the desired shade; filter as in No. 2648. Or: Dissolve madder lake in a solution of sesquicarbonate of ammonia, and dilute with water; filter as above.

2656. Violet. Dissolve nitrate of cobalt in a solution of sesquicarbonate of ammonia; add sufficient ammonio-sulphate of copper to produce the color. Filter as in No. 2648.

2657. Yellow. Dissolve ½ pound sesquioxide of iron (rust of iron), in 1 quart muriatic (hydrochloric) acid; dilute with water, and filter. (*See No.* 2648.) Or: Dissolve chromate or bichromate of potash in distilled water; or equal parts of either the above and of nitre (saltpetre) dissolved in water, and filtered as above.

2658. Crimson. To 1 ounce alkanet root add 1 pint oil of turpentine. Filter as directed in No. 2648. This is used chiefly for lamps.

2659. Green. Dissolve 2 ounces blue vitriol (sulphate of copper) in 1 pint water; add sufficient bichromate of potassa to turn the liquid green. Or: A solution of 2 ounces blue vitriol (sulphate of copper), and 4 ounces chloride of sodium, in 1 pint of water. Or: A solution of distilled verdigris, in acetic acid, and diluted with water. Or: Dissolve blue vitriol in water as above, and add nitric acid till it turns green. All these must be filtered as directed in No. 2648.

2660. Lilac. Dissolve crude oxide of cobalt in nitric or muriatic (hydrochloric) acid; add sesquicarbonate of ammonia, in excess; afterwards sufficient ammonio-sulphate of copper to produce the color required. Filter. (*See No.* 2648.)

2661. Olive. Dissolve equal parts by weight of sulphate of iron, and oil of vitriol, in water; add sufficient nitrate of copper to produce the color. Filter as in No. 2648.

2662. Orange. A solution of bichromate of potassa in water, either with or without the addition of some hydrochloric or sulphuric acid. Or: Dissolve gamboge or annotto in liquor of potassa; dilute with water and add a little spirit. Filter these as directed in No. 2648.

2663. Sea Green. To 1 gallon water add acetate of copper, 4 drachms; and acetic acid, 4 ounces.

2664. Pea Green. To 1 gallon water add nickel, 2 drachms; acetic acid, 1 ounce; and bichromate of potash, ½ drachm. Or: To 1 gallon diluted alcohol, add sulphate of copper and common salt, of each 2 ounces.

2665. Light Blue. To 1 gallon of water add sulphate of copper, 16 ounces.

2666. Light Green. Sulphate of copper (re-crystallized), muriatic acid (free from iron), water, alcohol, of each a sufficient quantity.

2667. Violet to Purple. To the green acid solution of sulphate of chromium add strong solution of ammonia, and filter as directed in No. 2648.

2668. Yellow. Bichromate of potassa, muriatic acid, water, of each a sufficient quantity.

2669. Bright Red. Cochineal, ground, 1 ounce. Boil with 1 pint of water, replacing that which evaporates. Towards the close

them, 2 or 3 coats of clean size should be applied with a brush.

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2668. Yellow. Bichromate of potassa, muriatic acid, water, of each a sufficient quantity.

2669. Bright Red. Cochineal, ground, 1 ounce. Boil with 1 pint of water, replacing that which evaporates. Towards the close add cream tartar, ¼ ounce; alum, 1 ounce; and when cold, oil of vitriol, 1 ounce, mixed with ¼ pint of water.

2670. Purple to Pink. Fuchsine diluted with spirit, as desired.

2671. Magenta, Solferino, Water of the Nile, and other bright colors may be obtained by mixing the various aniline or tar colors with water as directed in No. 2497.

2672. To Prevent Show Colors Freezing. It will be sufficient to bring the solution to a strength of about 15 to 20 per cent. of alcohol. Naturally the liquids must be very dilute as regards the solids, so as to suffer no precipitation of any saline matter by cold or spirits. Acetate of copper, with or without ammonia, a dilute solution of iodine in iodide of potassium, nitrate of cobalt, etc., are not acted on by weak alcohol. We believe that glycerine may be mixed with water for this purpose, but whether it possesses any superiority over alcohol we have not been able to ascertain. The bottles in all cases must have sufficient space left over the fluids to allow for expansion.

Pigments.

These are substances employed as coloring matter in mixing paints, &c. The following receipts furnish the method of preparing the pigments and other coloring matters in general use, and their special appliances.

2674. Turnbull's Prussian Blue. Ferricyanide (red prussiate) of potassium, 10 ounces; solution protosulphate of iron, 1 pint; water, 3 pints. Dissolve the ferricyanide of potassium in part of water, and add the solution, gradually, to the solution of protosulphate of iron previously diluted with the remainder of the water, stirring the mixture during the addition. Then filter the liquid, and wash the precipitate on the filter with boiling water until the washings pass nearly tasteless. Lastly, dry it, and rub it into fine powder. It may also be made by adding protosulphate of iron to a mixture of yellow prussiate of potash, chloride of soda, and hydrochloric acid. This, mixed with water, makes an excellent bluing.

2675. Prussian Blue. Percyanide, ferrocyanide, or ferroprussiate of iron. Commercial Prussian blue is made by adding to a solution of prussiate of potash (or of prussiate cake), a solution of 2 parts alum and 1 part sulphate of iron, washing the precipitate repeatedly with water to which a little muriatic acid has been added, and exposing it to the air till it assumes a deep blue color. A purer kind is made by adding a solution of persulphate or perchloride of iron to a solution of pure ferroprussiate of potash. (*See No.* 2674.)

2676. Action of Prussic Acid on Iron Solutions. The Germans call prussic acid blausäure, because it produces a blue precipitate in certain iron solutions; but the following experiment undoubtedly proves that the prussic acid does not produce the color of that precipitate, since it can be made just as well without it. Prepare a saturated solution of green vitriol in water. Take ⅓ parts of the above solution and treat it with nitric and sulphuric acids, until it is changed into the sulphate of peroxide of iron. Mix this with the remaining ⅓ of the first solution, then add very gradually (to avoid its becoming heated) concentrated sulphuric acid, until a precipitate is formed. The result will be a beautiful blue precipitate, equal to Prussian blue. If water is added, the precipitate is dissolved and the color destroyed; but if the precipitate is separated from the acid and rubbed with phosphate of soda, we obtain a beautiful blue phosphate of iron, which will resist the action of water. In all these cases the acids, which possess no color, are by no means the cause of the blue color, but favor only the production of it, by depriving the mixed hydrates of protoxide and peroxide of iron of certain equivalents of water, and likewise by preventing the same from entering into a higher state of oxidation in the atmosphere.

2677. To Make Carmine by the Langlois Process. Boiling river water, 4 gallons; cochineal in powder, 1 pound; boil for 10 minutes, then add ¼ ounce carbonate soda, dissolved in 1 pound water; boil again for ½ an hour; cool, add ¼ ounce alum in fine powder, agitate rapidly until it be dissolved, then let it stand for 20 minutes, after which carefully decant into another vessel. The white of 2 eggs, dissolved in 1 pint water, is now to be added, and the whole well agitated; apply heat until the liquor be clarified, then draw it off, and allow it to repose for ½ an hour, or longer, when the clear portion must be decanted, and the carmine that has been deposited at the bottom collected, and placed upon a filter to drain. When it has acquired the consistence of a paste, remove it from the filter with an ivory or silver knife, and finish the drying upon shallow plates, covered with silver paper.

2678. To Make Carmine by Cenette's Process. The following is the method employed by Madame Cenette: Finest cochineal, reduced to powder, 2 pounds; pure river water, boiling hot, 15 gallons; boil for 2 hours, then add refined saltpetre, bruised, 3 ounces; boil for 3 minutes longer, and add 4 ounces of salts of sorrel (binoxalate of potassa). Boil for 10 minutes longer, then remove the heat, and allow the liquor to settle for 4 hours, when it must be decanted with a syphon into shallow plates, and set aside for 3 weeks. At the end of this time, the film of mould formed on the surface must be dexterously and carefully removed, without breaking it or disturbing the liquid portion. The latter must be now removed with a syphon, and the remaining moisture drained off, or sucked up with a pipette. The carmine which is left behind must be dried in the shade, and will be found to possess extraordinary lustre and beauty.

2679. To Revive or Brighten Carmine. We may brighten ordinary carmine and obtain a very fine and clear pigment, by dissolving it in water of ammonia. For this purpose leave ammonia upon carmine in the heat of the sun till its color is extracted and the liquor has got a fine red tinge. It must then be drawn off and precipitated by acetic acid and alcohol, next washed with alcohol, and dried. Liquid carmine is a solution of carmine in ammonia.

2680. Adulteration of Cochineal. Genuine cochineal has a specific gravity of 1.25; it is commonly increased in weight by slightly moistening it with gum water, and then rouncing it in a bag, first with sulphate of baryta, and then with finely powdered bone-black. In this way its specific gravity is raised to 1.35, by introducing about 12 per cent. of useless matter.

2681. Kirchoff's Method of Making Vermilion. This is said to yield vermilion equal to the Chinese. Rub in a porcelain dish 100 parts mercury with 23 parts flowers of sulphur, moistening the mixture with a solution of caustic potash. Next treat it with 53 parts hydrate of potash, mixed with an equal weight of water; warm it up and triturate it again. The water must be replaced as it evaporates, and the operation continued for 2 hours. The whole is now to be evaporated to a thin paste, during constant trituration, and the heat removed the moment the color is of a good tint. Even a few seconds too much or too little will injure the result. When cold, the mass is washed with a solution of potash, and afterwards with pure water, and finally dried.

2682. To Preserve Vermilion. It is a fact well known to artists that the splendidly bright color of vermilion (cinnabar, sulphide of mercury) has a tendency, especially if it has been mixed with white lead, to become blackish brown and very dark-colored in a comparatively short time. This tendency is altogether obviated if, previous to being mixed with oil, it is thoroughly and intimately mingled with flowers of sulphur, in the proportion of 1 part sulphur to 8 parts vermilion.

2683. Carthamine or Safflower Lake. Wash safflower till the water comes off colorless; mix it with water holding 15 per cent. of carbonate of soda in solution, so as to form a thick paste; leave it for several hours, then press out the red liquid, and nearly neutralize it with acetic acid. Next put cotton into it, and add successive small portions of acetic acid, so as to prevent the liquid becoming alkaline. In 24 hours take out the cotton, wash it, and digest it for half an hour in water holding 5 per cent. of crystallized carbonate of soda in solution. Immediately on removing the cotton, supersaturate the liquid with citric acid, and collect the precipitate, which must be repeatedly washed in cold water. For pink saucers the liquid is allowed to deposit in the saucers. Mixed with the scrapings of French chalk it constitutes rouge.

2684. Lakes are also obtained from Brazil-wood and madder, by adding alum to a concentrated decoction of the former, or to a cold infusion of the latter (made by triturating the madder, inclosed in a bag, with the water), and afterwards sufficient subcarbonate of potash or soda to throw down the alumina in combination with the coloring matter. The precipitate is to be washed and dried. A little solution of tin added with the alum improves the color. Lakes may be obtained from most vegetable coloring matters by means of alum and an alkaline carbonate. Yellow lake is made from French or Persian berries, by boiling them in water with a little soda or potash, and adding alum to the strained liquor as long as a precipitate is thrown down. Or by boiling weld, or quercitron bark, in water, and adding alum and chalk in a pasty state.

2685. Rose Pink. Boil 6 pounds Brazil-wood and 2 pounds peach-wood in water, with ½ pound alum, and pour the strained decoction on 20 pounds sifted whiting.

2686. Sap Green. The expressed juice of buckthorn berries (and sometimes of other species of rhamnus, and also of privet berries) is allowed to settle, and the clear liquid evaporated to dryness. A little gum-arabic is sometimes added to the juice.

2687. Azure Blue, or Smalts. The common qualities are made by fusing zaffre (roasted cobalt ore calcined with siliceous sand) with potash. A finer quality is obtained by precipitating a solution of sulphate of cobalt, by a solution of silicate of potash. Another cobalt blue is obtained by adding a solution of phosphate of soda to a solution of nitrate of cobalt, and mixing the precipitate, washed, but not dried, with 8 times its weight of fresh hydrated alumina. When dry, heat it to a cherry red. It is permanent, but has little body. If ground too fine it loses its beautiful tint. It can be employed in fresco and silicious painting. It is not affected by sulphuretted hydrogen.

2688. Blue Verditer. It is generally stated to be made by adding chalk to a solution of nitrate of copper produced in the process of refining silver; but Mr. Phillips did not succeed in making it by this means, and found no lime in the best samples. This pigment is acted upon by suphurretted hydrogen; it should not be used in oil, and though more stable in water, it is hardly a pigment for high art work. Certain blues are made from the natural blue basic carbonate of copper, and from malachite, but they have no interest for the artist.

2689. New Blue. Mix equal parts of common arseniate of copper (*see Mineral Green, No.* 2711), and neutral arseniate of potash, fuse by heat in a large crucible, then add to the fused salt ⅛ its weight of nitre. Effervescence takes place, and the salt becomes blue. Cool, pulverize, and wash.

2690. Cobalt Blue. Thénard's blue is made by precipitating a soluble cobalt salt with a solution of alum, and heating the precipitate. When well made, it is a good permanent color, useful in oil and water. It can also be employed in fresco and silicious painting. It is, however, somewhat affected by light, losing its brilliancy slightly.

2691. Elsner's Preparation of Zinc Green. Sprinkle with water a mixture of 5 parts oxide of zinc and 1 part of sulphate of cobalt, dry the pulp thus obtained, then heat to redness. A deep green powder is obtained. If 10 parts oxide of zinc, and 1 part sulphate of cobalt be employed, the product is grass green in color; the same color, only lighter, is obtained when the latter proportion of zinc oxide is again doubled. These colors, especially the latter, may replace to advantage Schweinfurt green; they apply well on a coating of lime.

2692. Bistre. This is a brown color which is used in water-color painting. It is prepared from the root of beech-wood by washing away the soluble parts with water. The insoluble residue is mixed with gum water and formed into cakes.

2693. White Lead. This pigment, which enters largely into the composition of various colored paints, is carbonate of lead, obtained by suspending rolls of thin sheet lead over malt vinegar or pyroligneous acid in close vessels, the evaporation of the acid being induced and sustained by the heat of a steam-bath or other appliances.

2694. Test for White Lead. Commercial carbonate of lead is never quite pure, being commonly adulterated with sulphate of baryta, (heavy spar), and sometimes with chalk. The former may be detected by its insolubility in dilute nitric acid, and the latter by the nitric solution yielding a white precipitate with oxalic or sulphuric acid, or oxalate of ammonia, after having been treated with sulphuretted hydrogen, or a hydrosulphuret, to throw down the lead. (*Cooley.*)

2695. Simple Test for White Lead. Take a piece of firm, close-grained charcoal, and, near one end of it, scoop out a cavity about ½ inch in diameter and ¼ inch in depth. Place in the cavity a sample of the lead to be tested, about the size of a small pea, and apply to it continuously the blue or hottest part of the flame of a blow-pipe; if the sample be strictly pure, it will in a very short time, say in 2 minutes, be reduced to metallic lead, leaving no residue; but if adulterated to the extent of 10 per cent. only with oxide of zinc, sulphate of baryta, whiting or any other carbonate of lime (which substances are now the only adulterations used), or if it be composed entirely of these materials, as is sometimes the case with cheap lead, it cannot be reduced, but will remain on the charcoal an infusible mass. It is well, after blowing upon the sample, say for ½ a minute, by which time the oil will be burned off, to loosen the sample from the charcoal with a knife blade or spatula, in order that the flame may pass under as well as over and against it. With proper care the lead will run into one button, instead of scattering over the charcoal, and this is the reason why the cavity above mentioned is necessary. A common stearine candle or a lard oil lamp furnishes the best flame for use of the blowpipe; the flame of a coal oil lamp should not be used.

2696. Zinc White (oxide of zinc) is a permanent pigment; is not affected by sulphuretted hydrogen; does not form soap with oils and fats, therefore it retains its opacity; does not decompose other pigments, and if used with proper vehicles retains its whiteness. It is the best and safest white that can be used. It is most durable in silicious painting, as it forms chemical compounds with potash and silica.

2697. Sulphate of Baryta, called barytes and constant white, is very permanent, of a bluish tint; has no body in oil, but is a good white in fresco, silicious, and water-color painting. Chemically it has no action on other colors, and is not itself affected by any ordinary destructive agent. It is a natural product, called *heavy spar*.

2698. Pfundheller's Method of Obtaining Barytes White. For each 100 pounds of wool, 3 pounds alum, 1 pound cream of tartar, and 2 pounds sulphuric acid are to be combined with ½ ounce of soluble iodine violet, and the wool immersed in the solution at a temperature of 122° Fahr., and stirred round for an hour at this temperature. Another bath is to be made in the meantime, in a fresh kettle, with 3 pounds chloride of barium, and the whole immersed in this, and kept at a temperature of 122° Fahr., for two hours. By this process the sulphate of barytes, the most beautiful of whites, will be thrown down in the fibre of the wool, which has been saturated in the first bath with the sulphuric acid, and it will gain about eighteen per cent. in weight.

2699. Cremnitz White, a beautiful white, with less body than ordinary white lead; it is, doubtless, made by precipitation; it, like ordinary white lead, decomposes sulphides, and is decomposed by sulphuretted hydrogen.

2700. Cadmium Yellow, Red, etc. These are sulphides of cadmium, and, when well prepared, are very stable; they can be used in fresco and silicious painting. It is mentioned elsewhere that cadmium sulphide decomposes emerald green. (*See No.* 2712.) It is not safe to use it with lead pigments, unless it has been most carefully prepared; and here, inasmuch as decomposition may take place, and lead sulphide, which is black, be formed, it is better to avoid the mixture; no such mixture can occur in fresco or silicious painting, and it would be well if there were no chance of its occurring in any other style of painting, by the banishment of white lead from the list of artists' pigments. No other salts of cadmium are important as pigments.

2701. Green Oxide of Chromium. This oxide is perfectly stable, and, as so many tints of it can be obtained, including the beautiful vividian, it can be used in all vehicles, and is perfectly permanent in fresco and silicious painting. Other chromium compounds are used in painting; the chromates of lead have already been treated of. Chromate of barytes is a good, safe pigment; it is used under the name of lemon yellow. It is permanent in fresco and silicious painting. The chromates generally are unstable colors, and, as there are so many other good yellows, they should not be used as pigments.

2702. The Ochres are earths colored by oxide of iron. The natural color of these earths is yellow, but by burning they get darker, and some become red. Indian red, red ochre, light red, etc., are all earths with more or less of the oxide of iron in them. All the ochres are permanent and stable if they have been well prepared. They may be used safely in every style of painting.

2703. Colcothar is also an oxide of iron; it is very permanent, and generally useful as a pigment. It can be obtained of different tints. It is, however, especially useful in fresco and silicious painting.

2704. Venetian Red, as now prepared, is an iron red; but, whether from adulteration or not, it contains lime; and, as it is made from the sulphate of iron, sulphate of lime gets formed, and this prevents its employment in silicious painting, for with silicate of potash a silicate of lime is immediately formed, and it becomes hard and lumpy. It may be used in oil, water, and fresco.

2720. To Make Purple of Cassius. This is a vitrifiable pigment, which stains glass and porcelain a beautiful red or purple hue. Its preparation is one of great nicety, and is liable to fail even in the most experienced hands. Mix together separate solutions of 1 part crystallized protochloride of tin, and 2 parts crystallized perchloride of tin; this mixture, added to a solution of 1 part crystallized chloride of gold, makes a beautiful purple colored precipitate, which should immediately be washed, filtered, and dried. An excess of the protochloride produces a blue, yellow, or greenish tinge; the perchloride in excess gives a red or violet cast.

2721. French Purple of Cassius. This is similar in preparation to the last receipt, but differs in one ingredient employed, substituting perchloride of iron for the perchloride of tin. This purple keeps in the air unaltered for a long time.

2722. Purple of Cassius. To a moderately dilute solution of sesquichloride of iron, add a solution of protochloride of tin, until the mixture becomes green, and dilute the mixture with an equal bulk of water. Next prepare a solution of terchloride of gold, as neutral as possible, in the proportion of 1 part gold in 360 parts water; then add the tin solution, with constant stirring, as long as any precipitate is produced. Wash the precipitate as quickly as possible by decantation, and dry at a gentle heat.

2723. Buisson's Preparation of Purple of Cassius. Two solutions of tin are required. The *first* consists of a neutral solution of 1 part tin in nitric acid. The *second* is made by dissolving 2 parts tin in a mixture of 1 part hydrochloric acid with 3 parts nitric acid; a little heat may be cautiously applied towards the end of this process, to prevent any protoxide of tin from remaining in the solution.

Next dissolve 7 parts gold in an aqua-regia composed of 6 parts hydrochloric acid and 1 part nitric acid; and mix the solution at once with 3500 parts water; then add the whole of the *second* tin solution, subsequently adding by degrees the *first* tin solution, ceasing the moment the right color is obtained. Too little will produce a violet color; too much, a brown. Wash the precipitate very quickly, and dry. When dry it appears brown.

2724. Improved Vehicles for Colors. One measure of saturated solution of borax, with 4 of linseed oil. The pigment may be ground with the oil or the mixture. Or, a solution of shellac with borax, as in making Coathupe's ink. (*See No.* 2484.)

2725. Improved Vehicles for Water Colors. Water colors, mixed with gelatine, and afterwards fixed by washing with a solution of alum, or; curd of milk, washed and pressed, then dried on fine net, and when required for use, mixed with water and the coloring matter.

Drying Oils and Dryers.

All the fixed oils have an attraction more or less powerful for oxygen; and, by exposure to the air, they either become hard and resinous or sour and rancid. Those which exhibit the first property in a marked degree, as the oils of linseed, poppy, rape, and walnut, are called *drying* oils, and are used as vehicles for colors in painting. The drying property of oils is greatly increased by boiling them, either alone or with litharge, sugar of lead, etc., when the product forms the *boiled oil* or *drying oil* of commerce. The litharge and sulphate of lead employed for this purpose, may be again used, after washing them in hot water, to remove adhering mucilage. When paints are mixed with raw oil, as is frequently the case in house painting, the drying quality is obtained by the addition of compositions called *dryers*. These are generally made from Japan varnish, sugar of lead, litharge, etc., and are necessary in such paints as are preferably prepared without boiled oil.

2727. Dark Colored Boiled Oil. Simmer with frequent stirring, 1 gallon of linseed oil, with ¼ pound powdered litharge, until a skin begins to form; then remove the scum, and when it has become cold and has settled, decant the clear portions. This is for house painters' use.

2728. Pale Boiled Oil. Boil 1 quart linseed oil, and 2 ounces powdered white vitriol (sulphate of zinc), with 1 quart water, until the water has all evaporated; settle and decant as in the last receipt.

2729. Very Pale Drying Oil. Mix 2 ounces finely powdered litharge, or dry sulphate of lead, with 1 pint pale linseed or nut oil; agitate frequently for 10 days, then set the bottle in the sun or in a warm place to settle. When clear, decant it.

2730. Colorless Drying Oil for Paint. Take 5 gallons water, heat it to the boiling point in a vessel holding 15 gallons; when about to boil add 5 gallons linseed oil and 1 pound red lead. Keep it constantly boiling and stirred up for 2 hours over a slow fire. If not constantly stirred the lead will sink to the bottom and cause the oil to spatter. It is then taken from the fire and left to settle, when it will be found that the oil is clear and colorless.

2731. Mulder's Colorless Drying Oil. Boil linseed oil for two hours with 3 per cent. of red lead; filter it, and expose it to the sunshine in large shallow vessels, with a glass covering, frequently removing the cover to renew the air.

2732. To Make Boiled Oil Clear and Bright. There is often a difficulty in obtaining the oils *bright* after boiling or heating them with the lead solutions. The best way on a small scale is either to filter the boiled oil through coarse woolen filtering paper, or to expose it in a bottle for some time to the sun or in a warm place. In larger quantities, the oil may be filtered through Canton flannel bags.

2733. Artists' Drying Oil. Mix nut or pale linseed oil with about an equal measure of snow or powdered ice, and keep it for 2 months at a freezing temperature.

2734. Boiled Oil Specially Adapted for Zinc Paint. Mix 1 part binoxide of manganese, in coarse powder, but not dusty, with 10 parts nut or linseed oil; keep it gently heated and frequently stirred for about 30 hours, or until the oil begins to turn reddish. The oil thus prepared will also answer for any paint.

2735. New Drying Oil without Boiling. Mix with old linseed oil (the older the better), 2 per cent. of its weight of manganese borate (this salt is readily prepared by precipitating a solution of sulphate of manganese with a solution of borax, wash the precipitate, and dry it either at the ordinary temperature of the air or at 100°), and heat this mixture on a water-bath; or, if you have to work with large quantities, with a steam-bath to 100°, or at most 110°; you thus obtain a very excellent, light-colored, rapidly drying oil; by keeping the mixture stirred, that is to say, by always exposing fresh portions to air, the drying property of the oil is greatly promoted. The rapidity of the drying of the oil after it has been mixed with paint, on surfaces besmeared therewith, does not simply depend upon the drying property of the oil, but, in a very great measure, upon the state of the atmosphere—viz., whether dry or moist, hot or cold—the direct action of sunlight, and the state of the surfaces on which the paint is brought. Really genuine boiled linseed oil, if well prepared, leaves nothing to be desired as regards rapidity of drying, but it is retarded by various substances which are added in practice, among which, especially, oil of turpentine is injurious.

2736. Dryers for Dark-Colored Paints. This is prepared by grinding the best litharge to a paste with drying oil. A small portion is beaten up with the paint, when mixing with oil and turpentine for use.

2737. Dryers for Light-Colored Paints. Sulphate of zinc, or sugar of lead, mixed with drying oil, and used in the same way as the litharge in the last receipt.

2738. Dryers for White Paint. Mix 1 pound each sulphate of zinc and sugar of lead, with 2 pounds pure white (carbonate of) lead, and apply as in the last receipts.

2739. Patent Dryer. Mix the following ingredients to a paste with linseed oil: 15 pounds dry sulphate of zinc, 4 pounds sugar of lead, and 7 pounds litharge. The mixture should be passed 3 or 4 times through a paint mill. When a tin of this is in use, the surface should be always smoothed down level, and kept covered with a thin layer of linseed oil.

2740. Dryer for Zinc White. Mix together thoroughly 10 parts each sulphate of manganese, acetate of manganese, and sulphate of zinc, with 14½ parts zinc white. An addition of 2 or 3 per cent. of this dryer to zinc white oil paint will make it dry hard.

2741. To Make Japan Dryer. Into 1 gallon linseed oil, put ½ pound gum shellac; ½ pound each litharge, burned umber, and red lead; and 6 ounces sugar of lead. Boil together for 4 hours, or until all the ingredients are dissolved. Remove from the fire and add 1 gallon spirits of turpentine.

2742. Cheap Japan Dryer. Mix together 4 gallons pure linseed oil; 4 pounds each litharge and red lead; and 2 pounds powdered raw umber. Boil slowly for 2 hours, add by degrees 7½ pounds shellac, and boil ½ hour longer; when well mixed, add by degrees 1 pound powdered sulphate of zinc, and when nearly cold mix in thoroughly 7 gallons spirits of turpentine.

2743. To Make Paint Dry Quickly. To make paint dry quickly use a large proportion of Japan varnish in mixing.

2744. Massicot. Yellow protoxide of lead. The dross that forms on melted lead exposed to a current of air, roasted until it acquires a uniform yellow color. Used as a pigment, and in glazing. (*Cooley*).

House Painting.

The following directions are obtained from a thoroughly practical source, and will be found useful both to the amateur and the workman.

2746. Priming. The same paint is used for the first coat in outside and inside work; it should be as thick as will work conveniently, and requires only litharge for dryers. The paint should not be laid on too thickly, and well worked in with the brush.

2747. Priming for Iron Work. This must be oil color laid on a surface freed from rust. For paper and canvas, a coat of size takes the place of priming, as paint rots these materials.

2748. Puttying. This consists in filling up all nail-heads and cracks with putty, by a putty knife; and should always be done after priming.

2749. Second Coat for Outside Work. Mix the paint with raw oil, as thick as it can be used freely. Cover the surface, work it across to even it, and finish longways with long, light sweeps of the brush.

2750. Third Coat for Outside Work. The paint should be mixed with oil, a little thinner than for the second coat; laid on very evenly, and not too thickly, and finished as smooth as possible.

2751. Second Coat for Inside Work. The paint for this coat should be mixed with raw oil and turpentine, about equal parts, and be as thick as will work freely; laid on thinly and well crossed and finished to prepare a smooth surface, with as few ridges as possible, for the next coat.

2752. Third Coat for Inside Work. Mix the paint thinner than for the last coat, using but little oil, and more turpentine; laid on thinly and well finished, so as to leave no brush marks.

2753. Fourth Coat or Flatting for Inside Work. The paint is mixed with turpentine only, and thin enough to spread or flow even, before it sets; lay on evenly and quickly, brushing lengthways only, and finishing up as the work proceeds, as this paint sets quickly, and spots touched up afterwards are apt to be glossy.

2754. Drawn Flatting for a Fourth Coat. The oil in which the white lead or other paint is ground, is drawn out by mixing with turpentine, allowing the paint to settle, and then pouring off the liquid; repeating the operation with fresh turpentine till the oil has been completely washed out. This makes a better color, without gloss, and easily flowing. As it sets very quickly it must be applied thickly, evenly, and quickly, with closed doors and windows, to avoid a draught.

2755. When to Apply Paint. Paint, to last long, should be put on early in winter or spring, when it is cold and no dust flying. Paint put on in cold weather forms a body or coat upon the surface of the wood that becomes hard and resists weather, or an edged tool even, like slate.

2756. General Directions for House Painting. Oil paint dries with a gloss, turpentine makes a dead surface; and, in using paints containing both oil and turpentine, the gloss will be less as the proportion of oil is diminished. Paint requires more dryer in cold than in hot weather, but is more durable in outside work if applied in cold weather. Successive coats of paint should have at least a day intervene between them for drying. Dark colors should have a glossy finish. Before commencing to paint, the surface must be perfectly dry. The paint must be thoroughly mixed, both before commencing and during the progress of the work; if this is neglected, the heavy ingredients are apt to settle, leaving a larger proportion of oil and turpentine on the surface.

2757. Painter's Size. Stir a small quantity of litharge and red lead into some boiled oil; let it stand, shaking frequently until bleached; then bottle. Raw oil makes a slower drying size.

2758. Best Painter's Size. Heat raw oil in a pan till it emits a black smoke; set it on fire, and, after burning for a few minutes, cover the pan over to put out the blaze; pour the oil while warm into a bottle in which some pulverized red lead and litharge have been introduced. Stand the bottle in a warm place for two weeks, shaking often. It will then be ready to decant and bottle.

2759. To Paint Zinc. A difficulty is often experienced in causing oil colors to adhere to sheet zinc. Boettger recommends the employment of a mordant, so to speak, of the following composition: 1 part chloride of copper, 1 of nitrate of copper, and 1 of sal-ammoniac are to be dissolved in 64 parts of water, to which solution is to be added 1 part of commercial hydrochloric acid. The sheets of zinc are to be brushed over with this liquid, which gives them a deep black color; in the course of from 12 to 24 hours they become dry, and to their now dirty gray surface a coat of any oil color will firmly adhere. Some sheets of zinc prepared in this way, and afterwards painted, have been found to withstand all the changes of winter and summer.

2760. Polish White. This is made by grinding dry zinc-white with white varnish, and affords a beautiful glossy finish, to be laid on after the second coat. A more perfect surface may be obtained by covering the second coat with several other coats of hard drying paint, mixed with turpentine, Japan and litharge; then rubbing down with pumice-stone, followed by a coat of polish white, and finished with a flow coat of white varnish containing a little zinc-white. Although this requires more time and trouble, the result will fully compensate for it. It is necessary to remark that when the last coat is to be glossy, the previous coat must be flat or dead; and a flat coat for finishing should be preceded by a somewhat glossy coat.

2761. To Mix Oil Colors. In mixing different colored paints to produce any desired tint, it is best to have the principal ingredient thick, and add to it the other paints thinner. In the following table of the combinations of colors required to produce a required tint, the first named color is the principal ingredient, and the others follow in the order of their importance. Thus, in mixing a limestone tint, white is the principal ingredient, and red the color of which least is needed, &c. The exact proportions of each depending on the shade of color required.

2762. Table of Compound Colors, Showing the Simple Colors which Produce them.

Buff	White, Yellow Ochre, Red
Chestnut	Red, Black, Yellow
Chocolate	Raw Umber, Red, Black
Claret	Red, Umber, Black
Copper	Red, Yellow, Black
Dove	White, Vermilion, Blue, Yellow
Drab	White, Yellow Ochre, Red, Black
Fawn	White, Yellow, Red
Flesh	White, Yellow Ochre, Vermilion
Freestone	Red, Black, Yellow Ochre, White
French Gray	White, Prussian Blue, Lake
Gray	White Lead, Black
Gold	White, Stone Ochre, Red
Green Bronze	Chrome Green, Black, Yellow
Do Pea	White, Chrome Green
Lemon	White, Chrome Yellow
Limestone	White, Yellow Ochre, Black, Red
Olive	Yellow, Blue, Black, White
Orange	Yellow, Red
Peach	White, Vermilion
Pearl	White, Black, Blue
Pink	White, Vermilion, Lake
Purple	Violet, with more Red and White
Rose	White, Madder Lake
Sandstone	White, Yellow Ochre, Black, Red
Snuff	Yellow, Vandyke Brown
Violet	Red, Blue, White. *(See No. 2761.)*

2763. To Prepare Whitewashed Walls for Painting. If there should be any cracks in the plastering, and the wash be sound around the cracks, plaster of Paris is the best thing to fill them with, as it hardens quickly, does not shrink, and leaves the surface level with the wall. If the plaster of Paris sets before it can be worked, wet it with vinegar. The stronger the acid, the slower it will set. If cracks be filled with putty, and the wall be painted in gloss color, the streaks of putty are very apt to be flat (no gloss), and if painted in flat color, the streaks are quite sure to have a gloss. These streaks, of course, will spoil the beauty of the work, but do not affect its durability. When filled with plaster of Paris the reversion of gloss never appears, if done as directed below. If the cracks be only in the wash, the latter is loosening from the wall; and if it has not begun to scale, it soon will, and all attempts to fasten it on and paint it will be total loss. If it be loose enough to scrape off, scrape the wall, taking care not to gouge into the original wall. If not loose enough, let it alone until it is. If the wash be thin, solid, and even, it can be painted to look and wear well. When the surface is lumpy, rub the lumps off with a sandstone, or a brick. After a wall has been prepared, as in either of above cases, or if a wall that has never been washed is to be painted, size it with 2 coats of glue size (3 ounces glue to 1 gallon water). *(See No. 2815.)* Be sure the glue is all dissolved before using any of it. Let the first coat dry before the second coat is put on.

2764. To Paint Whitewashed Walls. When the second coat of glue size *(see No. 2763)* is dry, paint as follows: Mix the first coat of paint in the proportion of 1 gallon raw linseed oil to 15 pounds white lead, ground in oil, and 1 gill of dryer. Second coat: 1 gallon raw linseed oil, 25 pounds white lead ground in oil, and ½ gill dryer. (The lead should be the best.) Then finish either in gloss or flat color, the same as if it were wood work with one good coat of priming. Shade all the coats of paint, as near as you can, to the color you wish to finish in. Mix the third and fourth coats the same as the first, that is, about the same thickness for a gloss finish, and a little thinner for a flat finish.

2765. Flexible Paint for Canvas. Dissolve 2¼ pounds good yellow soap, cut in slices, in 1½ gallons boiling water; grind the solution while hot with 140 pounds good oil paint.

2766. Durable Black Paint for Out-Door Work. Grind powdered charcoal in linseed oil, with sufficient litharge as drier; thin for use with well-boiled linseed oil.

2767. Green Paint for Out-Door Work. Add to the black paint, made according to the last receipt, sufficient yellow ochre to make the shade of green required. This is preferable for garden work, to the bright green paint generally used, as it does not fade.

2768. Paint for Iron Work. There is no production for iron work so efficacious as well boiled linseed oil, properly laid on. The iron should be first well cleaned and freed from all rust and dirt; the oil should be of the best quality, and well boiled, without litharge or any dryer being added. The iron should be painted over with this, but the oil must be laid on as bare as possible, and on this fact depends in a great measure the success of the application; for if there be too thick a coat of oil put upon the work, it will skin over, be liable to blister, and scarcely ever get hard; but if iron be painted with three coats of oil, and only so much put on each coat as can be made to cover it by hard brushing, we will guarantee that the same will preserve the iron from the atmosphere for a much longer time than any other process of painting. If a dark coloring matter be necessary, we prefer burnt umber to any other pigment as a stain; it is a good hard dryer, and has many other good properties, and mixes well with the oil without injuring it.

2769. Painting in Milk. In consequence of the injury which has often resulted to sick and weakly persons from the smell of common paint, the following method of painting with milk has been adopted by some workmen, which, for the interior of buildings, besides being as free as distemper from any offensive odor, is said to be nearly equal to oil-painting in body and durability. Take ½ gallon skimmed milk, 6 ounces lime newly slacked, 4 ounces poppy, linseed, or nut oil, and 3 pounds Spanish white. Put the lime into an earthen vessel or clean bucket, and having poured on it a sufficient quantity of milk to make it about the thickness of cream, add the oil in small quantities at a time, stirring the mixture with a wooden spatula. Then put in the rest of the milk, and afterwards the Spanish white. It is, in general, indifferent which of the oils above mentioned you use; but, for pure white, oil of poppy is the best. The oil in this composition, being dissolved by the lime, wholly disappears; and, uniting with the whole of the other ingredients, forms a kind of calcareous soap. In putting in the Spanish white, be careful that it is finely powdered and strewed gently over the surface of the mixture. It then, by degrees, imbibes the liquid and sinks to the bottom. Milk skimmed in summer is often found to be curdled; but this is of no consequence in the present preparation, as its combining with the lime soon restores it to its fluid state. But it must on no account be sour; because in that case it would, by uniting with the lime, form an earthy salt, which could not resist any degree of dampness in the air.

2770. To Make Paint without Oil or Lead. Whiting, 5 pounds; skimmed milk, 2 quarts; fresh slacked lime, 2 ounces. Put the lime into a stone-ware vessel, pour upon it a sufficient quantity of the milk to make a mixture resembling cream; the balance of the milk is then to be added; and lastly the whiting is to be crumbled upon the surface of the fluid, in which it gradually sinks. At this period it must be well stirred in, or ground as you would other paint, and it is fit for use. There may be added any coloring matter that suits the fancy, to be applied in the same manner as other paints, and in a few hours it will become perfectly dry. Another coat may then be added, and so on until the work is done. This paint is of great tenacity, bears rubbing with a coarse cloth, has little smell, even when wet, and when dry is inodorous. It also possesses the merit of cheapness, the above quantity being sufficient for 57 yards.

2771. Paint for Old Weather-Boarding, or Boat Bottoms. Take 5 gallons boiled linseed oil, 4 gallons raw oil, 1 gallon benzine, and 80 pounds Rocky Mountain vermilion.

2772. Fireproof Paint. Take a quantity of the best quicklime, and slack with water in a covered vessel; when the slacking is complete, water or skim milk, or a mixture of both, should be added to the lime, and mixed up to the consistency of cream; then there must be added, at the rate of 20 pounds alum, 15 pounds potash, and 1 bushel salt to every 100 gallons of creamy liquor. If the paint is required to be white, 6 pounds plaster of Paris, or the same quantity of fine white clay, is to be added to the above proportions of the other ingredients. All these ingredients being mingled, the mixture must then be strained through a fine sieve, and afterwards ground in a color mill. When roofs are to be covered, or when crumbling brick walls are to be coated, fine white sand is mixed with the paint, in the proportion of 1 pound sand to 10 gallons of paint; this addition being made with a view of giving the ingredients a binding or petrifying quality. This paint should always be applied in a hot state, and in very cold weather precautions are necessary to keep it from freezing. Three coats of this paint are deemed, in most cases, sufficient. Any color may be obtained by adding the usual pigments to the composition.

2773. To Paint an Old House. Take 3 gallons water and 1 pint flax seed; boil ½ hour; take it off and add water enough to make 4 gallons; let it stand to settle; pour off the water in a pail, and put in enough of Spanish white to make it as thick as whitewash; then add ½ pint linseed oil; stir it well and apply with a brush. If the whiting does not mix readily, add more water. Flax seed, having the nature of oil, is better than glue, and will not wash off as readily.

2774. Paint for Boilers. The best paint for boilers is asphaltum dissolved in spirits of turpentine over a gentle fire. Pulverize the asphaltum and dissolve as much as will be taken up by the turpentine. If pure it will last.

2775. To Reduce Paint Skins to Oil. Dissolve ½ pound sal-soda in 1 gallon rain water. The skins that dry upon the top of paint which has been left standing for any length of time, may be made fit for use again by covering them with the sal-soda water and soaking them therein for a couple of days; then heat them, adding oil to reduce the mixture to a proper consistence for painting, and strain.

2776. To Remove the Smell of New Paint. Hay sprinkled with a little chloride of lime, and left for an hour in a closed room, will remove the smell of new paint.

2777. To Kill Knots before Painting. A mixture of glue size and red lead; or shellac dissolved in alcohol and mixed with red lead; or gutta-percha dissolved in ether; will, either of them, make a good coating for knots, but will not stand the sunshine, which will draw the pitch through the paint. The best method is to cover the knot with oil size, and lay a leaf of silver over it.

2778. To Kill Grease Spots Before Painting. Wash over smoky or greasy parts with saltpetre, or very thin lime whitewash. If soap-suds are used, they must be washed off thoroughly, as they prevent the paint from drying hard.

2779. To Make a Sticky Painted Surface Hard. Rub it well in, with a brush, with Japan and turpentine mixed together.

2780. To Prepare Plastered Walls for Painting. Plastered and hard finished walls must have a coating of glue size before painting. *(See No. 2815.)*

2781. To Economize Paint. Save all the skins, cleanings and scrapings of the paint pots, and wipings out of the brushes; these, boiled up in oil, make a cheap and durable coating for outside work. *(See No. 2775.)*

2782. To Remove Smalt from Old Signs. Spread over it, potash dissolved in water, and then scrape the smalt off. If the potash stands too long before scraping, it may soak into the wood; and paint afterwards put on will not dry well.

2783. To Remove Putty from Glass. Dip a small brush in nitric or muriatic acid, and with it paint over the dry putty that adheres to the broken glasses and frames of the windows. After an hour's interval the putty will have become so soft as to be easily removable.

2784. To Soften Putty in Window Frames. To soften putty in window frames, so that the glass may be taken out without breakage or cutting, take 1 pound American pearlash, 3 pounds quick stone lime, slack the lime in water, then add the pearlash, and make the whole about the consistence of paint. Apply it to both sides of the glass, and let it remain for 12 hours, when the putty will be so softened that the glass may be taken out of the frame without being cut, and with the greatest facility. *(See No. 2786.)*

2785. To Remove Hard Putty. This may be effected with a paste of caustic potassa, prepared by mixing the caustic alkali, or even carbonate of potash or soda, with equal parts of freshly burnt quicklime, which has previously been sprinkled with water, so as to cause it to fall into powder. This mixture is then made with water to a paste, and spread on the putty to be softened. Where one application is not sufficient, it is repeated. In order to prevent the paste from drying too quickly, it is well to mix it with less water, adding some soft-soap.

2786. For Removing Old Putty. For removing hard putty from a window-sash, take a square piece of iron, make the same red-hot, and run it along the putty till it gets soft. The putty will peel off without injuring the wood-work. Concentrated lye made of lime and alkali will affect the wood and make it rot quicker. *(See No. 2784.)*

2787. To Remove Paint from Old Work. To destroy paint on old doors, etc., lay the mixture in receipt No. 2784 over the whole body of the work which is required to be cleaned, with an old brush (as it will spoil a new one); let it remain for 12 or 14 hours, when the paint can be easily scraped off. These two receipts have been used by a practical painter and glazier for years.

2788. To Remove Paint from Wood. Where it is necessary to remove paint entirely, this is generally done by scraping; another way is to soften the paint by passing a flat flame over a portion of the surface at a time, and it can be scraped off easily while hot; but the method most recommended is to lay on a thick coating or plaster of fresh slacked lime mixed with soda; next day, wash it off with water, and it will remove the paint, leaving the surface clean.

2789. To Remove Paint from Stone. A correspondent of the London Builder, having to clean a pulpit and sedilia in which the carving and tracery were almost filled up with successive coats of paint, was informed that common washing-soda, dissolved in boiling water, and applied hot, would remove it. He found that 3 pounds of soda to a gallon of water, laid on with a common paint-brush, answered the purpose admirably, softening the paint in a short time, so that it was easily removed with a stiff scrubbing-brush; afterward, on adding a few ounces of potash to the solution, it softened more readily than with soda only. The stone in both cases was a fine freestone.

2790. To Soften Hard Putty. Break the putty in lumps of the size of a hen's egg, add a small portion of linseed oil, and water sufficient to cover the putty; boil this in an iron vessel for about 10 minutes, and stir it when hot. The oil will mix with the putty. Then pour the water off, and it will be like fresh made.

2791. To Clean Old Paint Cans, Buckets, etc. This can be thoroughly done with hot, strong lye.

2792. To Pencil or Point Brick Work. The upright as well as the horizontal lines should be drawn with a straight edge, as the least want of uniformity spoils the appearance of the brick work. White lead mixed with turpentine, and thick enough to set firm, is the best for this purpose.

Kalsomine and Whitewash.

The following receipts include the methods of preparing and applying white and other coatings on walls, etc., as well as the preparatory treatment of the surface to which they are to be applied, and other useful information.

2794. To Prepare Kalsomine. Kalsomine is composed of zinc white mixed with water and glue sizing. The surface to which it is applied must be clean and smooth. For ceilings, mix ¼ pound glue with 15 pounds zinc; for walls, 1 pound glue with 15 pounds zinc. The glue, the night before its use, should be soaked in water, and in the morning liquefied on the fire. It is difficult to prepare or apply kalsomine; few painters can do so successfully. Paris white is often made use of for it, but it is not the genuine article. *(See next receipt.)* The kalsomining mixture may be colored to almost any required tint by mixing appropriate coloring matter with it.

2795. To Kalsomine Walls. In case the wall of a large room, say 16 by 20 feet square, is to be kalsomined with two coats, it will require about ½ pound light-colored glue and 5 or 6 pounds Paris white. *(See last receipt.)* Soak the glue over night, in a tin vessel containing about a quart of warm water. If the kalsomine is to be applied the next day, add a pint more of clean water to the glue, and set the tin vessel containing the glue into a kettle of boiling water over the fire, and continue to stir the glue until it is well dissolved and quite thin. If the glue pail be placed in a kettle of boiling water, the glue will not be scorched. Then, after putting the Paris white into a large water pail, pour on hot water, and stir it until the liquid appears like thick milk. Now mingle the glue liquid with the whiting, stir it thoroughly, and apply it to the wall with a whitewash-brush, or with a large paint-brush. It is of little consequence what kind of an instrument is employed in laying on the kalsomine, provided the liquid is spread smoothly. Expensive brushes, made expressly for kalsomining, may be obtained at brush factories, and at some drug and hardware stores. But a good whitewash-brush, having long and thick hair, will do very well. In case the liquid is so thick that it will not flow from the brush so as to make smooth work, add a little more hot water. When applying the kalsomine, stir it frequently. Dip the brush often, and only so deep in the liquid as to take as much as the hair will retain without letting large drops fall to the floor. If too much glue be added, the kalsomine cannot be laid on smoothly, and will be liable to crack. The aim should be to apply a thin layer of sizing that cannot be brushed off with a broom or dry cloth. A thin coat will not crack.

2796. Whitewash for Out-Door Use. Take a clean water-tight barrel, or other suitable cask, and put into it ½ bushel lime. Slack it by pouring boiling water over it, and in sufficient quantity to cover 5 inches deep, stirring it briskly till thoroughly slacked. When slacking has been effected, dissolve in water and add 2 pounds sulphate of zinc and 1 of common salt. These will cause the wash to harden and prevent it from cracking, which gives an unseemly appearance to the work. If desirable, a beautiful cream color may be communicated to the above wash, by adding 3 pounds yellow ochre. This wash may be applied with a common whitewash-brush, and will be found much superior, both in appearance and durability, to common whitewash.

2797. Treasury Department Whitewash. This receipt for whitewashing, sent out by the Lighthouse Board of the Treasury Department, has been found, by experience, to answer on wood, brick and stone, nearly as well as oil paint, and is much cheaper. Slack ½ bushel unslacked lime with boiling water, keeping it covered during the process. Strain it, and add a peck of salt, dissolved in warm water; 3 pounds ground rice put in boiling water, and boiled to a thin paste; ½ pound powdered Spanish whiting, and a pound of clear glue, dissolved in warm water; mix these well together, and let the mixture stand for several days. Keep the wash thus prepared in a kettle or portable furnace, and, when used, put it on as hot as possible, with painters' or whitewash-brushes.

2798. To Color Whitewash. Coloring matter may be put in and made of any shade. Spanish brown stirred in will make red pink, more or less deep according to the quantity. A delicate tinge of this is very pretty for inside walls. Finely pulverized common clay, well mixed with Spanish brown, make a reddish stone color. Yellow ochre stirred in makes yellow wash, but chrome goes further, and makes a color generally esteemed prettier. In all these cases the darkness of the shades of course is determined by the quantity of coloring used. It is difficult to make rules, because tastes are different; it would be best to try experiments on a shingle and let it dry.

Green must not be mixed with lime. The lime destroys the color, and the color has an effect on the whitewash, which makes it crack and peel. When walls have been badly smoked, and you wish to have them a clean white, it is well to squeeze indigo plentifully through a bag into the water you use, before it is stirred in the whole mixture.

2799. Zinc Whitewash. Mix oxide of zinc with common size, and apply it with a whitewash-brush to the ceiling. After this, apply in the same manner a wash of chloride of zinc, which will combine with the oxide to form a smooth cement with a shining surface.

2800. A Fine Whitewash for Walls. Soak ½ pound of glue over night in tepid water. The next day put it into a tin vessel with a quart of water, set the vessel in a kettle of water over a fire, keep it there till it boils, and then stir until the glue is dissolved. Next put from 6 to 8 pounds Paris white into another vessel, add hot water, and stir until it has the appearance of milk of lime. Add the sizing, stir well, and apply in the ordinary way, while still warm. Except on very dark and smoky walls and ceilings, a single coat is sufficient. It is nearly equal in brilliancy to zinc-white (a far more expensive article), and is very highly recommended by those who have used it. Paris white is sulphate of baryta, and may be found at any drug or paint store.

2801. Fire-Proof Whitewash. Make ordinary whitewash and add 1 part silicate of soda (or potash) to every 5 parts of the whitewash. (*See No.* 2816.)

2802. Whitewash for Outside Work. Take of good quicklime ½ a bushel, slack in the usual manner and add 1 pound common salt, ½ pound sulphate of zinc (white vitriol), and 1 gallon sweet milk. The salt and the white vitriol should be dissolved before they are added, when the whole should be thoroughly mixed with sufficient water to give the proper consistency. The sooner the mixture is then applied the better.

2803. Whitewash for Fences or Out-Buildings. Slack the lime in boiling water, and to 3 gallons ordinary whitewash add 1 pint molasses and 1 pint table salt. Stir the mixture frequently while putting it on. Two thin coats are sufficient.

2804. To Mix Whitewash. Pour boiling water on unslacked lime, and stir it occasionally while it is slacking, as it will make the paste smoother. To 1 peck of lime add a quart of salt and ½ ounce of indigo dissolved in water, or the same quantity of Prussian blue finely powdered; add water to make it the proper thickness to put on a wall. 1 pound soap will give gloss.

2805. To Keep Whitewash. Keep the lime covered with water and in a tub which has a cover, to prevent dust or dirt from falling in. If the water evaporates the lime is useless, but if kept covered it will be good as long as any remains.

2806. To Whiten Smoked Walls. A method of cleaning and whitening smoked walls consists, in the first place, of rubbing off all the black, loose dirt upon them, by means of a broom, and then washing them down with a strong soda lye, which is to be afterward removed by means of water to which a little hydrochloric acid has been added. When the walls are dry a thin coating of lime, with the addition of a solution of alum, is to be applied. After this has become perfectly dry the walls are to be kalsomined or coated with a solution of glue and chalk.

2807. To Color, and Prevent Whitewash Rubbing Off. Alum is one of the best additions to make whitewash of lime which will not rub off. When powdered chalk is used glue water is also good, but would not do for outside work exposed to much rain. Nothing is easier than to give it any desired color by small quantities of lampblack, brown sienna, ochre, or other coloring material.

2808. To Paper Whitewashed Walls. The following method is simple, sure, and inexpensive: Make flour starch as you would for starching calico clothes, and, with a whitewash-brush, wet the wall you wish to paper, with the starch; let it dry; then, when you wish to apply the paper, wet the wall and paper both with the starch, and apply the paper. Walls have been papered in this way that have been whitewashed 10 or even 20 years successively, and the paper has never failed to stick. When you wish to re-paper the wall, with the brush wet the paper with clear water, and it will come off readily. (*See No.* 2811.)

2809. Red Wash for Bricks. To remove the green that gathers on bricks, pour over the bricks boiling water in which any vegetables (not greasy) have been boiled. Do this for a few days successively, and the green will disappear. For the red wash melt 1 ounce of glue in a gallon of water; while hot, put in a piece of alum the size of an egg, ½ pound Venetian red, and 1 pound Spanish brown. Try a little on the bricks, let it dry, and if too light add more red and brown; if too dark, put in more water. This receipt was contributed by a person who has used it for 20 years with perfect success.

Paper Hanging.

In cities, this is either a trade by itself, or is carried on as an adjunct to the painter's trade. In rural districts, however, there are many housekeepers who do this work for themselves. The following receipts are given for the guidance of housekeepers.

2811. To Prepare a Wall for Papering. A new unwhitewashed wall will absorb the paste so rapidly that, before drying, there will be left too little body of paste on the surface to hold the paper. A coating of good glue size, made by dissolving ½ pound of glue in a gallon of water (*see No.* 2815), or a coating of good paste, put on and allowed to dry before the paper is hung, will provide for this difficulty. If the wall be whitewashed, it should be scratched with a stiff brush, to remove every particle of loose lime from the surface; after which it should be thoroughly swept down with a broom, and coated with the glue size or thin paste. (*See No.* 2808.)

2812. Utensils for Paper Hanging. A long table of thin boards cleated together and placed on wooden horses, such as are used by carpenters, a pair of sharp shears—with long blades, if possible—a whitewash-brush, a pail for paste, and a yard of cotton cloth, are the implements required. The table or board platform should be level on its upper surface to facilitate the distribution of the paste. The latter should be free from lumps, and should be laid on as evenly as possible. It should be made of good sweet rye or wheat flour, beaten smooth in cold water before boiling, and should not be allowed to boil more than a minute or two, but should be raised to the boiling point slowly, being continually stirred till it is taken from the fire. (*See No.* 2272.)

2813. To Prepare Paper for Hanging. Inexpert hands often find difficulty in hanging the lengths of paper so as to make the patterns match. No general directions can be given for this, but a little study at the outset will often save cutting to waste, and other difficulties. In this matter, as in others, it is wise to "first be sure you are right, then go ahead." As soon as the proper way to cut the paper is decided upon, a whole roll, or more, may be cut at once, and the pieces laid, printed side downwards, upon the table, weights being placed upon the ends to prevent curling. The paste should then be applied to the back of the uppermost piece, as expeditiously as possible, as the longer the time employed in this part of the operation, the more tender will the paper get, and the more difficult it will be to hang it properly. About one-quarter of the length should be turned up at the bottom of the strip before hanging; as, without this, the bottom is apt to stick to the wall before the upper part of the strip can be adjusted. If the paper is very thick, both ends must be folded over, so as to meet in the middle. Besides being more convenient for handling, this allows the paper to soften, without the paste getting dry.

2814. To Apply Paper to Walls. The upper end of the piece should then be taken by the corners, and the operator, stepping upon a bench or step-ladder, should barely stick the piece at the top, and in such a manner that the edge shall coincide with the piece previously hung; this can be done by sighting down the trimmed edge of the piece, while it is held in the hands. The cloth should now be held in a loose bunch, and the paper smoothed with it from top to bottom, care being taken to work out all air from under the paper, which, if not thoroughly done, will give it a very unsightly blistered appearance. If any air remains under a part of the strip after it has been hung, a hole must be pricked through the paper with a pin, to allow of its escape. A *soft* flat whisk-brush (such as is used for brushing clothes) is better for smoothing the paper than a cloth. After the top is secured so that the pattern matches, brush once down the centre of the strip as far as the paste is exposed. Then carefully unfold the bottom of the strip, brush down the centre, and smooth the whole by brushing from the centre to the edges, right and left, all the way down, finishing with one sweep down the trimmed edge, to ensure a perfect join. A moist cloth should be always at hand to keep the figures clean and free from color. If the wall be uneven or crooked, as is often the case in old houses, it will be difficult to avoid wrinkles, but they can be mostly got rid of by cutting the paper and allowing the cut edges to lap over each other, in places where there would otherwise be a wrinkle. By following these directions the most inexperienced will be able to do a reasonably tidy piece of work, but of course a high degree of skill is only secured by practice.

2815. To Make Glue Sizing. Break up the glue into small pieces, put it in a vessel with sufficient cold water to just cover it; let it soak over night, and in the morning the glue will be soft enough to melt readily with a moderate heat, or in a water-bath. Add water to reduce to the desired consistency. This must be applied as directed in the foregoing receipts.

Soluble Glass.

This is a combination of silica with an alkali, soluble in boiling water, yielding a fine, transparent, semi-elastic varnish. When made according to Liemen's or Kuhlman's method, under increased pressure and heat, it is unaffected by cold water, and the object painted or covered by the same can only be deprived of its coating by undergoing the same heat and pressure as was required to prepare the original solution. Soluble glass prepared from potash is usually called *silicate of potash;* that from soda being *silicate of soda.* The most extensive use which is made, at present, of soluble glass produced after the other methods, is for the adulteration of soap; in fact, such a preparation is a kind of soap, in which the expensive fatty acids are replaced by the cheap silicic acid or sand; but it is a bad soap, very caustic, as the silicic acid but very imperfectly neutralizes the alkali. Another use of water glass is that of hardening cements, mortar, etc., so as to render them impermeable by water.

2817. Fuchs' Soluble Potash Glass. A mixture of 15 parts pulverized quartz, or pure quartz sand, 10 parts of well purified potash, and 1 part powdered charcoal, may be conveniently employed. These ingredients are to be well mixed and exposed to a strong heat in a fire-proof melting-pot for 5 or 6 hours, until the whole fuses uniformly and steadily; as much heat is required as is necessary to melt common glass. The melted mass is then taken out by means of an iron spoon, and the melting-pot immediately refilled with a fresh quantity. (At this stage of the process it is said by another authority, that, by pulverizing and exposing it to the air, it will absorb acidity, and by degrees the foreign salts will, after frequent agitation and stirring, be completely separated, particularly after pouring over the mass some cold water, which dissolves them, but not the soluble glass.) It is then broken up, pulverized, and dissolved in about 5 parts of boiling water, by introducing it in small portions into an iron vessel and constantly stirring the liquid, replacing the water as it evaporates, by adding hot water from time to time, and continuing to boil for 3 or 4 hours, until the whole is dissolved—a slimy deposit excepted—and until a pellicle begins to form on the surface of the liquid, which indicates that the solution is in a state of great concentration; it disappears, however, when the liquid is stirred; and the boiling may then be continued for a short time, in order to obtain the solution in the proper state of concentration, when it has a specific gravity of from 1.24 to 1.25 (about 28° Baumé). In this state it is sufficiently liquid to be used in many operations; in some instances it will be necessary to dilute it with more or less water. When evaporated to a syrupy consistence, it can be employed with advantage in but few cases. Very frequently it is found contaminated with a little sulphide of potassium, and it becomes necessary to add a little oxide of copper or copper scales towards the end of the boiling, which liberates a small quantity of potash, but which renders it rather more suitable for many practical purposes than otherwise. If it is desirable, however, to have a water-glass which is entirely neutral, it requires to be boiled with freshly-precipitated silica as long as any silica is dissolved.

2818. Fuchs' Soluble Soda Glass. This is prepared in the same way as the potash glass (*see No.* 2817), with the exception that a smaller proportion of soda is required. A mixture of 45 parts by weight of quartz, 23 parts dry carbonate of soda, and 3 parts charcoal, may be employed. The mixture fuses somewhat easier than potash glass.

2819. Buchner's Soluble Soda Glass. Take 100 parts quartz, 60 parts dry sulphate of soda, and 15 to 20 parts charcoal. This is said to be cheaper than that made with carbonate of soda, and is prepared in the same manner. By the addition of some copper scales to the mixture the sulphur will be separated. Another method is proposed by dissolving the fine silex in caustic soda lye. Kuhlman employs the powdered flint, which is dissolved in an iron caldron under a pressure of 7 to 8 atmospheres of steam. Liebig has recommended infusorial earth in place of sand, on account of its being readily soluble in caustic lye; and he proposes to use 120 parts of the earth to 75 parts of caustic soda, from which 240 parts of silica jelly may be obtained. His mode is to calcine the earth so as to become white, and passing it through a sieve. The lye he prepares from 75 ounces of calcined soda, dissolved in 5 times the quantity of boiling water, and then treated by 56 ounces of dry slacked lime; this lye is concentrated by boiling down to 48° Baumé; in this boiling lye 120 ounces of the prepared infusorial earth are added by degrees, which are readily dissolved, leaving scarcely any sediment. It has then to undergo several operations for making it suitable for use, such as treating again with lime-water, boiling it and separating any precipitate, which by continued boiling forms into balls, and which can then be removed from the liquid. This clear liquid is then evaporated to the consistency of syrup; it forms a jelly slightly colored, feels dry and not sticky, and is readily soluble in boiling water. The difference between potash and soda soluble glass is not material; the first may be preferred in whitewashing with plaster of Paris, while the soda glass is more fluidly divisible.

2820. To Distinguish Potash and Soda Soluble Glass. By adding ½ volume of rectified alcohol to a concentrated solution of soluble potash glass, a gelatinous precipitate is formed, which, in a few days, is deposited at the bottom of the vessel in a solid mass. The addition of alcohol to soluble soda glass converts it into a gelatinous mass, but affords no precipitate.

2821. To Make Wood Incombustible. The application of soluble glass to wood renders it almost incombustible.

2822. Double Soluble Glass. A mixture of 3 parts by measure of concentrated potash soluble glass, and 2 parts concentrated soda glass, produce a double water-glass which will answer all practical purposes.

The following preparation is also recommended by Fuchs, as being much easier to fuse. Take 100 parts quartz, 28 parts purified potash, 22 parts neutral dry carbonate of soda, and 6 parts powdered charcoal.

2823. Soluble Glass for Stereo-Chromic Painting. Soluble glass for the use of stereo-chromic painting is obtained by fusing 3 parts of pure carbonate of soda and 2 parts of powdered quartz, from which a concentrated solution is prepared, 1 part of which is then added to 4 parts of a concentrated and fully saturated solution of potash-glass solution, by which there is a more condensed amount of silica with the alkalies; this solution has been found to work well for paint. Siemens' patent for the manufacture of soluble glass consists in the production of a liquid quartz by digesting the sand or quartz in a steam-boiler tightly closed and at a temperature corresponding to 4 or 5 atmospheres, with the common caustic alkalies, which are in this way capacitated to dissolve from 3 to 4 times the weight of silica to a thin liquid. Experience has taught that the soluble glass made in the old way, with an excess of alkali, cannot stand the influence of the atmosphere when used as a paint. The soda washes out, and leaves the silex in a pulverized condition, so that it soon disappears. When, however, a closed boiler is used, according to Kuhlman's or Siemens' method, and a pressure of 7 or 8 atmospheres, which corresponds with a temperature of some 120° above the boiling point of water, the solvent qualities of the latter are increased to such an extent as to enable it to dissolve a glass containing ½ to ⅓ the amount of potash or soda.

To Dye Wood. Dyeing wood is mostly applied for giving color to veneers, while staining is more generally had recourse to, to give the desired color to an article after it has been manufactured. In the one case, the color should penetrate throughout, while in the latter the surface is all that is essential. After the veneers are cut, they should be allowed to lie in a trough of water for 4 or 5 days before being put into the copper; as the water brings out abundance of slimy matter, which, if not thus removed, would prevent the wood taking a good color. After this purifying process, the veneers should be dried in the open air for at least 12 hours. They are then ready for the copper. By this simple method, the color will strike much quicker, and be of a brighter hue. It would also add to the quality of the colors, if, after the veneers have boiled a few hours, they are taken out, dried in the air, and again immersed in the coloring copper. Always dry veneers in the open air, for fire invariably injures the colors. (*See Nos.* 2837, *etc.*)

2825. Fine Black Dye for Wood. Put 6 pounds chip logwood into the copper, with as many veneers as it will conveniently hold, without pressing too tight; fill it with water, and let it boil slowly for about 3 hours; then add ½ pound powdered verdigris, ½ pound copperas, and 4 ounces bruised nut-galls; fill the copper up with vinegar as the water evaporates; let it boil gently 2 hours each day till the wood is dyed through.

2826. Fine Yellow Dye for Wood. Reduce 4 pounds of barberry root by sawing, to dust, which put in a copper or brass trough; add 4 ounces turmeric and 4 gallons water, then put in as many white holly veneers as the liquor will cover; boil them together for 3 hours, often turning them; when cool, add 2 ounces aquafortis, and the dye will strike through much sooner.

2827. Bright Yellow Dye for Wood. To every gallon of water necessary to cover the veneers, add 1 pound French berries; boil the veneers till the color has penetrated through; add some brightening liquid (*see next receipt*) to the infusion of the French berries, and let the veneers remain for 2 or 3 hours, and the color will be very bright.

2828. Liquid For Brightening and Setting Colors. To every pint of strong aquafortis, add 1 ounce grain tin, and a piece of sal-ammoniac the size of a walnut; set it by to dissolve, shake the bottle round with the cork out, from time to time: in the course of 2 or 3 days it will be fit for use. This will be found an admirable liquid to add to any color, as it not only brightens it, but renders it less likely to fade from exposure to the air.

2829. Fine Blue Dye for Wood. Into a clean glass bottle put 1 pound oil of vitriol, and 4 ounces best indigo pounded in a mortar (take care to set the bottle in a basin or earthen glazed pan, as it will effervesce), put the veneers into a copper or stone trough; fill it rather more than ⅓ with water, and add as much of the vitriol and indigo (stirring it about) as will make a fine blue, which you may know by trying it with a piece of white paper or wood; let the veneers remain till the dye has struck through. The color will be much improved if the solution of indigo in vitriol be kept a few weeks before using it. The color will also strike better if the veneers be boiled in plain water till completely soaked through, and left for a few hours to dry partially, previous to immersing them in the dye.

2830. Bright Green Dye for Wood. Proceed as in either of the previous receipts to produce a yellow; but instead of adding aquafortis or the brightening liquid, add as much vitriolated indigo (*see last receipt*) as will produce the desired color.

2831. Bright Red Dye for Wood. To 2 pounds genuine Brazil dust, add 4 gallons water; put in as many veneers as the liquor will cover; boil them for 3 hours; then add 2 ounces alum, and 2 ounces aquafortis, and keep it lukewarm until it has struck through.

2832. Red Dye for Wood. To every pound of logwood chips, add 2 gallons water; put in the veneers, and boil as in the last; then add a sufficient quantity of the brightening liquid (*see No.* 2828), till the color is of a satisfactory tint; keep the whole as warm as you can bear your finger in it, till the color has sufficiently penetrated. The logwood chips should be picked from all foreign substances with which it generally abounds, as bark, dirt, &c.; and it is always best when fresh cut, which may be known by its appearing of a bright red color; for if stale, it will look brown, and not yield so much coloring matter.

2833. Rose Colored Dye for Wood. Mouier produces a fine pink or rose-color on wood of cellulose, especially that of the ivory nut, by immersing it first in a solution of iodide of potassium, 1½ ounces per pint of water, in which it remains for several hours, when it is placed in a bath of corrosive sublimate, 135 grains to the pint. When properly dyed it is washed and varnished over. We should think that less poisonous materials might be found to answer the same purpose.

2834. Bright Purple Dye for Wood. Boil 2 pounds logwood, either in chips or powder, in 4 gallons water, with the veneers; after boiling till the color is well struck in, add by degrees vitriolated indigo (*see No.* 2829), till the purple is of the shade required, which may be known by trying it with a piece of paper; let it then boil for 1 hour, and keep the liquid in a milk-warm state till the color has penetrated the veneer. This method, when properly managed, will produce a brilliant purple.

2835. Orange Dye for Wood. Let the veneers be dyed by either of the methods given for a fine deep yellow (*see Nos.* 2826 *and* 2827), and while they are still wet and saturated with the dye, transfer them to the bright red dye (*see No.* 2821), till the color penetrates equally throughout.

2836. Silver-Gray Dye for Wood. Expose any quantity of old iron, or, what is better, the borings of gun-barrels, &c., in any convenient vessel, and from time to time sprinkle them with muriatic acid, diluted in 4 times its quantity of water, till they are very thickly covered with rust; then to every 6 pounds add 1 gallon of water in which has been dissolved 2 ounces salt of tartar (carbonate of potassa); lay the veneers in the copper, and cover them with this liquid; let it boil for 2 or 3 hours till well soaked, then to every gallon of liquor add 1 pound of green copperas, and keep the whole at a moderate temperature till the dye has sufficiently penetrated.

2837. To Dye Veneers. Some manufacturers of Germany, who had been supplied from Paris with veneers, colored throughout their mass, were necessitated by the late war to produce them themselves. Mr. Puscher states that experiments made in this direction gave in the beginning colors fixed only on the outside, while the inside was untouched, until the veneers were soaked for 24 hours in a solution of caustic soda containing 10 per cent. of soda, and boiled therein for ¼ hour; after washing them with sufficient water to remove the alkali, they may be dyed throughout their mass. This treatment with soda effects a general disintegration of the wood, whereby it becomes, in the moist state, elastic and leather-like, and ready to absorb the color; it must then, after dyeing, be dried between sheets of paper and subjected to pressure to retain its shape.

2838. To Dye Veneers Black. Veneers treated as in last receipt and left for 24 hours in a hot decoction of logwood (1 part logwood to 3 water), removing them after the lapse of that time, and, after drying them superficially, putting them into a hot solution of copperas (1 part copperas to 30 water), will, after 24 hours, become beautifully and completely dyed black.

2839. To Dye Veneers Yellow. A solution of 1 part picric acid in 60 water, with the addition of so much ammonia as to become perceptible to the smell, dyes veneers yellow, which color is not in the least affected by subsequent varnishing. Before dyeing, the veneers require the preparatory treatment given in No. 2837.

2840. To Dye Veneers Rose-Color. Coralline dissolved in hot water, to which a little caustic soda and one-fifth of its volume of soluble glass has been added, produces rose-colors of different shades, dependent on the amount of coralline taken. (*See No.* 2837.)

2841. To Dye Veneers Silver-Gray. The only color which veneers will take up, without previous treatment of soda, is silver-gray, produced by soaking them for a day in a solution of 1 part copperas to 100 parts water.

To Stain Wood.

Staining wood is altogether a different process from dyeing it, and requires no preparation before the stain be applied. In preparing the stain, but little trouble is required; and, generally speaking, its application differs very little from that of painting. When carefully done, and properly varnished, staining has a very beautiful appearance, and is much less likely to meet with injury than japanning.

2843. Black Stain for Immediate Use. Boil ½ pound chip logwood in 2 quarts water, add 1 ounce pearlash, and apply it hot to the work with a brush. Then take ½ pound logwood, boil it as before in 2 quarts water, and add ½ ounce verdigris and ½ ounce green copperas; strain it off, put in ½ pound rusty steel filings; with this, go over the work a second time.

2844. To Stain Wood Like Ebony. Take a solution of sulphate of iron (green copperas), and wash the wood over with it 2 or 3 times; let it dry, and apply 2 or 3 coats of a strong hot decoction of logwood; wipe the wood, when dry, with a sponge and water, and polish with linseed oil.

2845. To Stain Wood Light Mahogany Color. Brush over the surface with diluted nitrous acid, and when dry apply the following, with a soft brush: dragon's blood, 4 ounces; common soda, 1 ounce; spirit of wine, 3 pints. Let it stand in a warm place, shake it frequently, and then strain. Repeat the application until the proper color is obtained.

2846. To Stain Dark Mahogany Color. Boil ½ pound madder and 2 ounces logwood in 1 gallon water; then brush the wood well over with the hot liquid. When dry, go over the whole with a solution of 2 drachms pearlash in 1 quart water.

2847. To Stain Mahogany Color. Pure Socotrine aloes, 1 ounce; dragon's blood, ½ ounce; rectified spirit, 1 pint; dissolve, and apply 2 or 3 coats to the surface of the wood; finish off with wax or oil tinged with alkanet. Or: Wash over the wood with strong aquafortis, and when dry, apply a coat of the above varnish; polish as last. Or: Logwood, 2 ounces; madder, 8 ounces; fustic, 1 ounce; water, 1 gallon; boil 2 hours, and apply it several times to the wood boiling hot; when dry, slightly brush it over with a solution of pearlash, 1 ounce, in water, 1 quart; dry and polish as before. Or: Logwood, 1 part; water, 8 parts. Make a decoction and apply it to the wood; when dry give it 2 or 3 coats of the following varnish dragon's blood, 1 part; spirits of wine, 2 parts. Mix.

2848. Beechwood Mahogany. Dissolve 2 ounces dragon's blood and 1 ounce aloes in 1 quart rectified spirit of wine, and apply it to the surface of the wood previously well polished. Or: Wash over the surface of the wood with aquafortis, and when thoroughly dry give it a coat of the above varnish. Or: Boil 1 pound logwood chips in 2 quarts water, and add 2 handfuls of walnut peel; boil again, then strain, and add 1 pint good vinegar; apply as above.

2849. Artificial Mahogany. The following method of giving any species of wood of a close grain the appearance of mahogany in texture, density, and polish, is said to be practiced in France with success. The surface is planed smooth, and the wood is then rubbed with a solution of nitrous acid; 1 ounce dragon's blood is dissolved in nearly a pint of spirits of wine; this, and ⅓ ounce carbonate of soda, are then to be mixed together and filtered, and the liquid in this thin state is to be laid on with a soft brush. This process is to be repeated, and in a short interval afterwards the wood possesses the external appearance of mahogany. When the polish diminishes in brilliancy, it may be restored by the use of a little cold-drawn linseed oil.

2850. Fine Black Stain. Boil 1 pound logwood in 4 quarts water, add a double handful of walnut-peel or shells; boil it up again, take out the chips, add 1 pint best vinegar, and it will be fit for use; apply it boiling hot. This will be improved by applying a hot solution of green copperas dissolved in water (an ounce to a quart), over the first stain.

2851. To Imitate Rosewood. Boil ½ pound logwood in 3 pints water till it is of a very dark red; add ½ ounce salt of tartar (carbonate of potassa). While boiling hot, stain the wood with 2 or 3 coats, taking care that it is nearly dry between each; then, with a stiff flat brush, such as is used by the painters for graining, form streaks with the black stain above named (*see last receipt*), which, if carefully executed, will be very nearly the appearance of dark rosewood; or, the black streaks may be put in with a camel's hair pencil, dipped in a solution of copperas and verdigris in a decoction of logwood. A handy brush for the purpose may be made out of a flat brush, such as is used for varnishing; cut the sharp points off, and make the edges irregular, by cutting out a few hairs here and there, and you will have a tool which will accurately imitate the grain.

2852. To Imitate Rosewood. Stain with the black stain (*see No.* 2850); and when dry, with a brush dipped in the brightening liquid (*see No.* 2828), form red veins, in imitation of the grain of rosewood, which will produce a beautiful effect.

2853. New Stain for Wood. Permanganate of potassa is recommended as a rapid and excellent stain for wood. A solution of it spread upon pear or cherry wood, for a few minutes, leaves a permanent dark brown color, which, after careful washing, drying, and oiling, assumes a reddish tint upon being polished.

2854. Stolzel's Method of Staining Wood Brown. Dr. Stolzel adds another to the many receipts already given for staining wood of a brown color. First of all paint over the wood with a solution made by boiling 1 part of catechu (Cutch or Gambier) with 30 parts water and a little soda. This is allowed to dry in the air, and the wood is then painted over with another solution made of 1 part bichromate of potash and 30 parts water. By a little difference in the mode of treatment, and by varying the strength of the solutions, various shades of color may be given with these materials, which will be permanent and tend to preserve the wood.

2855. To Darken Light Mahogany. When furniture is repaired, it frequently happens that the old wood cannot be matched, and therefore the work presents a patched appearance. To prevent this, wash the pieces introduced, with soap-lees, or dissolve quicklime in water, and use in the same manner; but be careful not to let either be too strong, or it will make the wood too dark; it is best, therefore, to use it rather weak at first, and, if not dark enough, repeat the process till the wood is sufficiently darkened.

2856. Black Walnut Stain. Take 1 quart water, 1½ ounces washing soda, 2½ ounces vandyke brown, ½ ounce bichromate of potassa. Boil for 10 minutes, and apply with a brush either in a hot or cold state. This is an excellent stain. (*See Nos.* 2853 *and* 2854.)

2857. To Improve the Color of any Stain. Mix in a bottle 1 ounce of nitric acid, ½ tea-spoonful muriatic acid, ¼ ounce grain tin, and 2 ounces rain water. Mix it at least 2 days before using, and keep the bottle well corked.

2858. To Stain Musical Instruments and Fancy Boxes. Fancy work necessitates the employment of brighter colors than those used for furniture; we therefore give the following receipts for preparing and applying those most commonly employed for such purposes.

2859. Fine Crimson Stain. Boil 1 pound good Brazil dust in 3 quarts water for an hour; strain it, and add ½ ounce cochineal; boil it again gently for ½ an hour, and it will be fit for use. If required of a more scarlet tint, boil ½ ounce saffron in 1 quart of water for an hour, and pass over the work previous to the red stain.

2860. Fine Green Stain. To 3 pints strongest vinegar, add 4 ounces best verdigris pounded fine, ½ ounce sap green, and ½ ounce indigo. Distilled vinegar, or verjuice, improves the color.

2861. Purple Stain. To 1 pound good chip logwood, put 3 quarts water; boil it well for an hour; then add 4 ounces pearlash, and 2 ounces pounded indigo.

2862. Fine Blue Stain. Into 1 pound oil of vitriol (sulphuric acid) in a clean glass phial, put 4 ounces indigo, and proceed as above directed in dyeing purple.

2863. Bright Yellow Stain. Wood need not be stained yellow, as a small piece of aloes put into the varnish will have the desired effect.

2864. Fine Black Stain. As a general thing, when black is required in musical instruments, it is produced by japanning; the work being well prepared with size and lampblack, apply the black japan (*see No.* 2322), after which, varnish and polish. But as a black stain is sometimes required for finger-boards, bridges, and flutes, proceed as directed in staining (*see No.* 2850); the wood, however, ought to be either pear, apple, or boxwood; the latter is preferable; and if it be rubbed over, when dry, with a rag or flannel dipped in hot oil, it will give it a gloss equal to ebony.

2865. To Stain Boxwood Brown. Hold the work to the fire, that it may receive a gentle warmth; then take aquafortis, and with a feather pass over the work until it changes to a fine brown (always keeping it near the fire); then oil and polish it.

2866. Cane Staining. By the following simple process, canes and similar sticks may be stained a rich brown: Dissolve a few grains sulphate of manganese in sufficient water to take it up; moisten the surface of the cane with it, and hold it over the flame of a spirit lamp close enough to scorch it. By care, the whole surface may be brought to a uniform rich brown, or beautifully variegated by heating some parts more than others; thus varying the color from white to the deepest black. The color will appear dull at first; but, on oiling it with raw linseed oil, and rubbing it with a smooth piece of hard wood, it will be beautifully developed. Give the cane no other finish, unless it be another oiling some days after the first.

Varnish.

Varnish. Varnishes may be conveniently divided into two kinds, viz., spirit and oil varnishes. Concentrated alcohol is used as the solvent in the former, and fixed or volatile oils, or mixtures of the two, for the latter. The specific gravity of alcohol for the purpose of making varnishes should not be greater than 0.820 (that is, not below about 93 per cent). Camphor is often dissolved in it to increase its solvent powers. The oil of turpentine, which is the essential oil chiefly employed, should be pure and colorless. Pale drying linseed oil is the fixed oil generally used for varnishes, but poppy and nut oil are also occasionally employed. Among the substances employed in the manufacture of varnishes are turpentine, copal, mastich, lac, elemi, sandarach, anime, and amber, to impart body and lustre; benzoin to impart scent; gamboge, turmeric, saffron, annotto, and Socotrine aloes, to give a yellow color; dragon's blood to give a red tinge; asphaltum to give a black color and body; caoutchouc to impart body, toughness, and elasticity. Varnish constitutes a distinct branch of manufacture, and many of them can be advantageously or safely made only on the large scale on premises adapted for the purpose.

2868. Preparation of Linseed Oil for Making Oil Varnishes. In the manufacture of oil varnishes, one of the most important points is the use of good drying oil. Linseed oil for this purpose should be pale, limpid, brilliant, scarcely odorous, and mellow and sweet to the taste. 100 gallons of such oil are put into an iron or copper boiler capable of holding 150 gallons, and gradually heated to a gentle simmer for 2 hours, to expel moisture; the scum is then carefully removed, and 14 pounds scale litharge, 12 pounds red lead, and 8 pounds powdered umber (all carefully dried and free from moisture), are gradually sprinkled in; the whole is then kept well stirred, to prevent the dryers sinking to the bottom, and the boiling is continued at a gentle heat, for 3 hours longer; the fire is next withdrawn, and, in 24 to 36 hours, the scum is carefully removed, and the clear oil decanted from the bottom. This forms the best boiled or drying oil.

2869. Clarified Oil for Varnish. When boiled oil is used for making varnish, and a still further clarifying is deemed advisable, it is placed in a copper pan holding from 80 to 100 gallons, and heat gradually applied till the scum rises, after removing which the oil is allowed to boil for about 2 hours, when it is dosed with calcined magnesia, in the proportion of an ounce to every 4 gallons of oil, but added by degrees and with occasional stirrings. This being completed, the oil is again boiled briskly for about an hour, and then, the furnace being drawn, allowed to cool. When the temperature is sufficiently reduced, it is removed to leaden cisterns, where it is stored till fit for use.

2870. Clarified Linseed Oil for Varnishes. Heat in a copper boiler 50 gallons of linseed oil to 280° Fahr.; add 2½ pounds of calcined white vitriol, and keep the oil at the above temperature for ½ hour; then remove it from the fire, and in 24 hours decant the clear oil, which should stand for a few weeks before it is used for varnish.

2871. Wilks' Refined Linseed Oil. In 236 gallons oil pour 6 pounds oil of vitriol, and stir them together for 3 hours; then add 6 pounds fullers' earth, well mixed with 14 pounds hot lime, and stir for 3 hours. Put the oil into a copper boiler, with an equal quantity of water, and boil for 3 hours; then extinguish the fire, and when the materials are cold draw off the water, and let the oil stand to settle for a few weeks before using.

2872. Boiled Oil for Varnishes. Mix 100 gallons linseed oil and 7 pounds calcined white vitriol (sulphate of zinc) in fine powder, in a clean copper boiler; heat it to 285° Fahr., and keep it at that temperature for at least an hour, constantly stirring it; then allow it to cool; in 24 hours decant the clear portion, and in 3 or 4 weeks rack it for use.

2873. Cautions Respecting the Making of Varnish. As heat in many cases is necessary to dissolve the gums used in making varnish, the best way, when practicable, is to use a sand-bath, which is simply placing the vessel containing the varnish, in another filled with sand and placed on the fire. This will generally be sufficient to prevent the spirits catching fire; but to avoid such an accident (which not unfrequently happens), it will be best to take a vessel sufficiently large to prevent any danger of spilling its contents; indeed, the vessel should never be more than two-thirds filled. However, a piece of board sufficiently large to cover the top of the vessel should always be at hand in case the spirits should take fire; as also a wet wrapper, in case it should be spilled, as water itself thrown on would only increase the mischief. The person who attends the varnish-pot should have his hands covered with gloves, and, if they are made of leather, and rather damp, it will effectually prevent injury. These cautions should be well observed, or shocking personal injury may result from their neglect. In the city, it is hardly worth while to make varnish, unless in large quantities, as there are many stores where it may be had very good, and at a fair price; but in the country, where the freight is an object, and you cannot depend upon the genuineness of the article, it is necessary to be known by the practical mechanic how to make it; when it is available, it is best to purchase it. The varnish generally sold for varnishing furniture is white hard varnish.

Oil Varnishes. These, the most durable and lustrous of varnishes, are composed of a mixture of resin, oil, and spirit of turpentine. The oils most frequently employed are linseed and walnut; the resins chiefly used are copal and amber, and some other gums. The drying power of the oil having been increased by litharge, red lead, or by sulphate of lead, and a judicious selection of copal having been made, it is necessary, according to Booth, to bear in mind the following facts before proceeding to the manufacture of varnish: 1. That varnish is not a solution, but an intimate mixture of resin with boiled oil and spirit of turpentine. 2. That the resin must be completely fused previous to the addition of the boiled or prepared oil. 3. That the oil must be heated from 250° to 300°. 4. That the spirit of turpentine must be added gradually, and in a thin stream, while the mixture of oil and resin is still hot. 5. That the varnish be made in dry weather, otherwise moisture is absorbed, and its transparency and drying quality impaired. Of late years it has been practically demonstrated that not only is there no necessity for boiling the oil and gum after incorporation, but that the produce is equally good if the turpentine be added just before the mixture becomes too cold to permit of a perfect amalgamation. In fact, it is now acknowledged that the oil need not be raised to a higher temperature than that at which the gum employed fuses, and that when the two are mixed the lowest possible degree of heat which will insure their incorporation, is sufficient to secure all the results desired. By this method a large quantity of the turpentine formerly lost in evaporation is saved, and there is, moreover, less risk of fire. The heating vessel must be of copper, of a capacity at least one-third more gallons than the mixture to be introduced into it, with a riveted and not a soldered bottom. To promote the admixture of the copal with the hot oil, the copal—carefully selected and of nearly uniform fusibility—is separately heated with continuous stirring over a moderate charcoal fire kept constantly supplied with fuel, without disturbing the kettle until the completion of the mixture with the oil. If the copal is melted in the hot oil, the resulting varnish is more colored and less drying. There is, however, great care required in fusing the copal by itself; for if the heat is too much prolonged, the resin becomes pitchy, and gives an inferior varnish. Constant stirring is requisite to prevent adhesion to the sides and bottom of the vessel, and consequent scorching. The pieces of copal should be of uniform fusibility; the different varieties, therefore, should not be fused together, for that which melts first is apt to scorch before the more refractory are fused. If it is desired to mix different varieties, they should be fused separately and then mixed in fluid state. When the resin is thoroughly melted, the hot oil is to be ladled in gradually during constant stirring. To determine when sufficient oil has been added, a drop must be now and then taken out and cooled upon a glass plate. If, on cooling, it is limpid and wax-like, penetrable with the nail without cracking, the proportion of oil is sufficient; if, however, it is hard and brittle, more oil is required. Some resins absorb more oil than others. The spirits of turpentine should be heated, and added in a thin stream to the oil and resin while still hot. Care must be taken not to add the turpentine while the mixture is too hot, as too much of the turpentine will be lost by evaporation; but if the mixture gets too cool it becomes sticky, the addition of turpentine must be stopped, and it must be replaced over the fire and heated gradually up to 600°. Limpidity is thus restored, and, upon removal from the fire, sufficient turpentine should be added to impart the proper consistence; but this extra heating injures the quality of the varnish.

2875. Common Oil Varnish. Resin, 3 pounds; drying oil, ½ gallon; melt together, and add, when removed from the fire, 2 quarts warm oil of turpentine.

2876. Oil Copal Varnish. Pale hard copal, 2 pounds; fuse, add hot drying oil, 1 pint; boil as before directed, and thin with oil of turpentine, 3 pints, more or less, as found necessary. Very pale. Dries hard in 12 to 24 hours.

2877. Best Pale Carriage Varnish. Pale African copal, 8 pounds; fuse, and add clarified linseed oil, 2½ gallons; boil till very stringy, then add dried copperas and litharge, of each ¼ pound; boil as before directed, thin with oil of turpentine, 5½ gallons; mix while hot with the following varnish, and immediately strain the mixture into a covered vessel: Gum anime, 8 pounds; clarified linseed oil, 2½ gallons; dried sugar of lead and litharge, of each ¼ pound; boil as before, thin with oil of turpentine, 5½ gallons, and mix it while hot with the last varnish as above directed. Dries in 4 hours in summer and 6 in winter. Used for the wheels, springs, and carriage parts of coaches and other vehicles, and by house painters, decorators, &c., who want a strong, quick-drying, and durable varnish.

2878. Ordinary Carriage Varnish. Sorted gum anime, 8 pounds; clarified oil, 3 gallons; litharge, 5 ounces; dried and powdered sugar of lead and white copperas, of each 4 ounces; boil as last, and thin with oil of turpentine, 5½ gallons.

2879. Amber Varnish. Amber, 1 pound; pale boiled oil, 10 ounces; turpentine, 1 pint. Render the amber, placed in an iron pot, semi-liquid by heat; then add the oil, mix, remove it from the fire, and, when cooled a little, stir in the turpentine. Or: To the amber, melted as above, add 2 ounces of shellac, and proceed as before. This varnish is rather dark, but remarkably tough. The first form is the best. It is used for the same purposes as copal varnish, and forms an excellent article for covering wood, or any other substance not of a white or very pale color. It dries well, and is very hard and durable.

2880. Black Amber Varnish. Amber, 1 pound; boiled oil, ½ pint; powdered asphaltum, 6 ounces; oil of turpentine, 1 pint. Melt the amber, as before described, then add the asphaltum, previously mixed with the cold oil, and afterwards heated very hot; mix well, remove the vessel from the fire, and, when cooled a little, add the turpentine, also made warm. Each of the above two varnishes should be reduced to a proper consistence with more turpentine if it be required. The last form produces the beautiful black varnish used by the coachmakers. Some manufacturers omit the whole or part of the asphaltum, and use the same quantity of clear black resin instead, in which case the color is brought up by lampblack reduced to an impalpable powder, or previously ground very fine with a little boiled oil. The varnish made in this way lacks, however, that richness, brilliancy, and depth of blackness imparted by asphaltum.

2881. Pale Amber Varnish. Amber, pale and transparent, 6 pounds; fuse, add hot clarified linseed oil, 2 gallons; boil till it strings strongly, cool a little, and add oil of turpentine, 4 gallons. Pale as copal varnish; soon becomes very hard, and is the most durable of oil varnishes; but requires time before it is fit for polishing. When wanted to dry and harden quicker, drying oil may be substituted for linseed, or dryers may be added during the boiling.

2882. Tough Amber Varnish. Amber, 1 pound; melt, add Scio turpentine, ½ pound; transparent white resin, 2 ounces; hot linseed oil, 1 pint; and afterwards sufficient oil of turpentine as above. Very tough.

2883. Hard Amber Varnish. Melted amber, 4 ounces; hot boiled oil, 1 quart; as before.

2884. Very Pale Amber Varnish. Very pale and transparent amber, 4 ounces; clarified linseed oil and oil of turpentine, of each 1 pint; as before. Amber varnish is suited for all purposes where a very hard and durable oil varnish is required. The paler kind is superior to copal varnish, and is often mixed with the latter to increase its hardness and durability.

2885. Varnish for Waterproof Goods. Let ¼ pound of India-rubber, in small pieces, soften in ½ pound of oil of turpentine, then add 2 pounds boiled oil, and let the whole boil for 2 hours over a slow coal fire. When dissolved, add again 6 pounds boiled linseed oil and 1 pound litharge, and boil until an even liquid is obtained. It is applied warm, and forms a waterproof coating.

2886. India-Rubber Oil Varnish. Take 4 ounces India-rubber in fine shavings, dissolve in a covered jar by means of a sand-bath, in 2 pounds of crude benzole, and then mix with 4 pounds hot linseed oil varnish, and ½ pound oil of turpentine. Dries well.

2887. India-Rubber Oil Varnish. Cut up 1 pound India-rubber into small pieces and diffuse in ½ pound sulphuric ether, which is done by digestion in a glass flask on a sand-bath. Then add 1 pound pale linseed oil varnish, previously heated, and after settling, 1 pound oil of turpentine, also heated beforehand. Filter, while yet warm, into bottles. Dries slowly.

2888. Gutta-Percha Oil Varnish. Clean ½ pound gutta-percha in warm water from adhering impurities, dry well, dissolve in 1 pound of rectified resin oil, and add 2 pounds linseed oil varnish, boiling hot. Very suitable to prevent metals from oxidation.

2889. Champagnat's India-Rubber Varnish. In a wide-mouthed glass bottle, digest 2 ounces India-rubber in fine shavings, with 1 pound oil of turpentine, during 2 days, without shaking, then stir up with a wooden spatula. Add another pound oil of turpentine, and digest, with frequent agitation, until all is dissolved. Then mix 1½ pounds of this solution with 2 pounds of very white copal oil varnish, and 1½ pounds well boiled linseed oil; shake and digest in a sand-bath, until they have united in a good varnish. For morocco leather.

2890. Flexible Varnish. Melt 1 pound of resin, and add gradually ½ pound India-rubber in very fine shavings, and stir until cold. Then heat again, slowly, add 1 pound linseed oil varnish, heated, and filter.

2891. Flexible Varnish. Dissolve 1 pound of gum damar, and ½ pound India-rubber in very small pieces, in 1 pound oil of turpentine, by means of a water-bath. Add 1 pound hot oil varnish and filter.

2892. Hair Varnish. Dissolve 1 part of clippings of pigs' bristles, or of horse-hair, in 10 parts of drying linseed oil by heat. Fibrous materials (cotton, flax, silk, &c.), imbued with the varnish and dried, are used as a substitute for hair-cloth.

2893. Cabinet Varnish. Fuse 7 pounds African copal, and pour on it 4 pints hot clarified linseed oil; in 3 or 4 minutes, if it feels stringy, take it out of the building, where there is no fire near, and when it has cooled to 150° mix in 3 gallons oil of turpentine of the same temperature, or sufficient to bring it to a due consistence.

2894. Bessemer's Varnish for Metallic Paint. This is made with 8 pounds copal, 2½ gallons drying oil, and 25 gallons oil of turpentine. These are made into a varnish nearly as directed for Cabinet Varnish (*see No.* 2893); and afterwards mixed with a gallon of slacked lime and left for 3 days to settle. The clear portion is then drawn off, and 5 parts of varnish mixed with 4 parts of bronze powder.

2895. Mahogany Varnish. Sorted gum anime, 8 pounds; clarified oil, 3 gallons; litharge and powdered dried sugar of lead, of each ¼ pound; boil till it strings well, then cool a little, thin with oil of turpentine, 5½ gallons, and strain.

2896. Italian Varnish. Boil Scio turpentine till brittle; powder, and dissolve in oil of turpentine. Or: Canada balsam and clear white resin, of each 6 ounces; oil of turpentine, 1 quart, dissolved. Used for prints, engravings, &c.

2897. Varnish for Printers' Ink. To every 10 pounds clarified linseed oil add 5 pounds clear black resin, and ½ pound oil of turpentine. It is then ready for mixing with lampblack or other coloring matter. A twelfth part of Canada balsam is sometimes added for the finer parts.

2898. Varnish for Frames for Hot Beds. Mix 4 ounces pulverized white cheese, 2 ounces slacked lime, and 4 ounces boiled linseed oil. Mix, and add 4 ounces each whites and yolks of eggs, and liquefy the mixture by heat. This curious mixture is said to produce a pliable and transparent varnish.

2899. Brunswick Black. Foreign asphaltum, 45 pounds; drying oil, 6 gallons; and litharge, 6 pounds. Boil for 2 hours, then add dark gum-amber (fused), 8 pounds; hot linseed oil, 2 gallons. Boil for 2 hours longer, or until a little of the mass, when cooled, may be rolled into pills. Then withdraw the heat, and afterwards thin down with 25 gallons oil of turpentine. Used for iron-work, &c.

2900. Black Varnish for Iron-Work. Asphaltum, 48 pounds, fuse; add boiled oil, 10 gallons; red lead and litharge, of each 7 pounds; dried and powdered white copperas, 3 pounds. Boil for 2 hours; then add dark gum amber (fused), 8 pounds; hot linseed oil, 2 gallons; boil for two hours, proceeding as in the last receipt, thinning down with oil of turpentine, 30 gallons. Used for the same purposes as Brunswick black.

2901. Colored Oil Varnishes. Oil varnishes are colored by grinding with them the most transparent colors, as distilled verdigris for green, &c. Spirit varnishes are also colored with dragon's blood, gamboge, &c. (*See No.* 2867.)

2902. Varnish for Grates. To 2 pounds common asphaltum, fused in an iron pot, add 1 pint hot boiled linseed oil; mix well and boil for some time. When partially cooled add 2 quarts oil of turpentine. If too thick, add turpentine. Apply with an ordinary paint brush.

Spirit Varnishes.

The spirit employed for making spirit varnishes should not be less than 95 per cent. In preparing and using them, they should be kept at a distance from a candle or other flame. Respecting the gums (resins) employed, it may be useful to mention that shellac is rendered more soluble by being powdered and exposed for a long time to the air (*see No.* 2906); sandarach gives hardness to varnishes; mastich gives a gloss to a solution of other gums; benzoin still more, but its color is objectionable; anime readily dissolves, but renders the varnish long in drying; copal and amber are scarcely soluble in spirit, but are rendered partially so by other gums, and also by being previously fused by heat. (*See No.* 2867.) Shellac gives a durable varnish, objectionable only on account of its color, which may be rendered paler by charcoal. (*Beasley.*) (*See No.* 1723, *&c.*) In the preparation of spirit varnishes, care should be taken to prevent the evaporation of the alcohol as much as possible, and also to preserve the portion that evaporates. On the small scale, spirit varnishes are best made by maceration in close bottles. In order to prevent the agglutination of the resin, it is often advantageously mixed with clear silicious sand, or pounded glass, by which the surface is much increased, and the solvent power of the menstruum promoted. The tendency of a spirit varnish to chill or give a rough surface may be destroyed by adding to the varnish a little gum sandarach, oil of lavender or concentrated ammonia.

2904. To Dissolve Copal in Spirit. Take the copal and expose it in a vessel formed like a cullender to the front of a fire, and receive the drops of melted gum in a basin of cold water; then dry them well in a temperature of about 95° Fahr. By treating copal in this way it acquires the property of dissolving in alcohol.

2905. Copal Varnish. Take 1 ounce copal and ½ an ounce shellac; powder them well, and put them into a bottle or jar containing 1 quart spirits of wine. Place the mixture in a warm place, and shake it occasionally, until the gums are completely dissolved; and, when strained, the varnish will be fit for use. The above is the simplest, and therefore the most usual method of making common copal varnish; but it may be prepared in a variety of ways, where particular uses may be required.

2906. To Dissolve Gum Shellac. Everybody who has ever to deal with bleached gum shellac knows the difficulties and the loss of time attending its solution. To obviate this, the gum is broken into small pieces and macerated in a stoppered bottle with ether; after swelling up sufficiently, the excess of ether is poured off, when it will dissolve quite readily in alcohol. (*See No.* 2903.)

2907. Copal Varnish. Take 3 ounces copal, melt by a gentle heat, and drop it into water (*see No.* 2904); then dry it and powder it fine. Place a bottle containing 1 pint oil of turpentine in a water-bath, and add the powdered copal to the turpentine in small portions at a time; in a few days decant the clear. Dries slowly, but is very pale and durable, and is used for pictures, &c. In making this varnish, it frequently happens that the gum will not melt as readily as it ought, which, in general, is owing to the turpentine not being sufficiently rectified; but, when that is good, it will always succeed. It is best also to let the turpentine be exposed for some time in the sun, in a corked bottle, that the watery particles may be gradually dissipated. The bottle should not be stopped quite tight.

2908. Copal Varnish, according to Professor Boettger should be made by first dissolving 1 part by weight of camphor, in 12 parts ether; when the camphor is dissolved, 4 parts best copal resin, previously reduced to an impalpable powder, are added to the ethereal camphor solution placed in a well-stoppered bottle. As soon as the copal appears to be partly dissolved, and has become swollen, 4 parts strong alcohol, or methylated spirits, and ½ part oil of turpentine are added, and, after shaking the mixture and letting it stand for a few hours longer, a thoroughly good copal varnish is obtained.

2909. Common Turpentine Varnish. This is merely clear pale resin dissolved in oil of turpentine; usually 5 pounds resin to 7 pounds of turpentine.

2910. Crystal Varnish. Picked mastich, 4 ounces; rectified spirit, 1 pint; animal charcoal, 1 ounce. Digest and filter.

2911. Mastich Picture Varnish. Very pale and picked gum mastich, 5 pounds; glass pounded as small as barley, and well washed and dried, 2½ pounds; rectified turpentine, 2 gallons; put them into a clean 4 gallon stone or tin bottle, bung down securely, and keep rolling it backwards and forwards pretty smartly on a counter or any other solid place, for at least 4 hours; when, if the gum is all dissolved, the varnish may be decanted, strained through muslin into another bottle, and allowed to settle. It should be kept for 6 or 9 months before use, as it thereby gets both tougher and clearer. Very fine.

2912. Mastich Varnish. Mastich, 8 pounds; turpentine, 4 gallons; dissolve by a gentle heat, and add pale turpentine varnish, ½ gallon.

2913. Best Mastich Varnish. Gum mastich, 6 ounces; oil of turpentine 1 quart; dissolve. Mastich varnish is used for pictures, &c.; when good, it is tough, hard, brilliant, and colorless.

2914. Varnish for Paintings. Take mastich, 6 ounces; pure turpentine, ½ ounce; camphor, 2 drachms; spirits of turpentine, 19 ounces; add first the camphor to the turpentine; the mixture is made in a water-bath; when the solution is effected, add the mastich and the spirits of turpentine near the end of the operation; filter through a cotton cloth.

2915. Tingry's Essence Varnish. Mastich in powder, 12 ounces; pure turpentine, 1½ ounces; camphor, ½ ounce; powdered glass, 5 ounces; rectified oil of turpentine, 1 quart.

2916. White Toy Varnish. Tender copal, 7½ ounces; camphor, 1 ounce; alcohol of 95 per cent., 1 quart; dissolve, then add mastich, 2 ounces; Venice turpentine, 1 ounce; dissolve and strain. Very white, drying, and capable of being polished when hard. Used for toys.

2917. White Varnish. Sandarach, 8 ounces; mastich, 2 ounces; Canada balsam, 4 ounces; alcohol, 1 quart. Used on paper, wood, or linen.

2918. Best White Hard Varnish. Rectified spirits of wine, 1 quart; gum sandarach, 10 ounces; gum mastich, 2 ounces; gum anime, ½ ounce; dissolve these in a clean can, or bottle, in a warm place, frequently shaking it. When the gum is dissolved, strain it through a lawn sieve, and it is fit for use.

2919. Mordant, or Transfer Varnish. Mastich in tears, 6½ ounces; resin, 12½ ounces; pale Venice turpentine (genuine) and sandarach, of each 25 ounces; alcohol, 5 pints; dissolve as before. Used for fixing engravings or lithographs on wood, and for gilding, silvering, &c. (*See No.* 2928.)

2920. Map Varnish is prepared by pulverizing 1 ounce sandarach, ½ ounce mastich, ½ ounce elemi, dissolving them in ½ ounce of Venice turpentine, and adding to it a solution of 4 ounces shellac, and 3 ounces oil of lavender, in 12 ounces alcohol. (*See No.* 2935.)

2921. Canada Varnish. Clear balsam of Canada, 4 ounces; camphene, 8 ounces; warm gently, and shake together till dissolved. For maps, drawings, &c., they are first sized over with a solution of isinglass, taking care that every part is covered; when dry, the varnish is brushed over it.

2922. Collodion Varnish. The addition of 1 part castor oil to 32 parts collodion, makes a good varnish; it dries rapidly and does not penetrate the paper. This varnish will do very well for coating maps, lists, labels, etc., and it will keep for years. If, after a repeated coating, white spots should appear, moisten them with ether, and they will vanish instantly.

2923. Varnish to Imitate the Chinese. Put 4 ounces powdered gum-lac, with a piece of camphor about the size of a hazelnut, into a strong bottle, with 1 pound good spirits of wine. Shake the bottle from time to time, and set it over some hot embers to mix for 24 hours, if it be in winter; in summer time it may be exposed to the sun. Pass the whole through a fine cloth, and throw away what remains upon it. Let it settle for 24 hours; separate gently the clear part in the upper part of the bottle, and put into another phial; the remains will serve for the first layers or coatings.

2924. Varnish for Drawings and Lithographs. Take of dextrine, 2 parts; alcohol, ¼ part; water, 2 parts. These should be prepared previously with 2 or 3 coats of thin starch or rice boiled and strained through a cloth. (*See No.* 2927.)

2925. To Purify Dextrine. Hager gives a method for rendering dextrine pure, or at least freer from foreign odor and taste. For this purpose he dissolves 10 parts of good dextrine, with stirring, in 18 of cold distilled water, allows the mixture to stand for some days, decants and strains it from the sediment. The clear liquid is then to be mixed with once and a half to twice its volume of alcohol fortius (*see No.* 1439); after some hours the liquor is separated from the pasty mass, which is then once more dissolved in a small quantity of water, and spread on glass or porcelain to dry at a temperature not exceeding 140° Fahr.

2926. Le Blond's Varnish. Keep 4 pounds balsam of copaiba warm in a sand or water bath, and add 16 ounces copal (previously fused and coarsely powdered), by single ounces, daily, and stir it frequently. When dissolved add a little Chio turpentine.

2927. De Sylvestre's Dextrine Varnish. Dextrine, 2 parts; water, 6 parts; rectified spirit, 1 part. (*See No.* 2924.)

2928. Transfer Varnish. For transferring and fixing engravings or lithographs on wood, and for gilding, silvering, etc. Dissolve 4 ounces mastich (in tears), and 4 ounces sandarach, in 1½ pints rectified spirit; add ½ pint pure Canada balsam. (*See No.* 2919.)

2929. To Dissolve Amber. There is no difficulty in dissolving amber in chloroform, but people are apt to think they fail, from the circumstance that it is only partially soluble. Take some broken amber, reduce to a coarse powder, and place in a bottle with rather more than enough chloroform to cover them well; shake often, and in a few days, by pouring a drop or two of the clear liquid on a glass plate, a varnish of good body, which gives a strong glaze, may be obtained. Or an amber varnish may be made as follows: Take of amber, 3 ounces; benzole, 50 ounces; heat the amber in a closed vessel to a temperature of about 570° Fahr. When it begins to soften and swell, emitting white fumes, then dissolve in the benzole.

2930. Amber Varnish for Photographs. Dissolve 3 to 4 grains amber in 1 ounce chloroform. (*See No.* 2929.)

2931. Brilliant Amber Spirit Varnish. Fused amber, 4 ounces; sandarach and mastich, of each 4 ounces; highly rectified spirit, 1 quart. Expose to the heat of a sand-bath, with occasional agitation, till dissolved. (The amber is fused in a close copper vessel, having a funnel-shaped projection, which passes through the bottom of the furnace by which the vessel is heated.)

2932. Hare's Colorless Varnish for Photographs. Dissolve shellac by heat in 8 parts of water and 1 of pearlash. Precipitate by chlorine, and dissolve in rectified spirit. (*See Nos.* 2933 to 2935.)

2933. Bookbinders' and Colorless Varnish. Mr. A. Schmidt gives the following directions for making these and several other beautiful varnishes: For 1 pound good shellac take 4 ounces crystallized carbonate of soda, and 1½ gallons water; put the whole in a clean iron or copper vessel of double the capacity, and, under constant stirring, bring it to boiling over a slow fire. The shellac will dissolve, and, if it is intended to make colorless French varnish (*see No.* 2935), the solution has to be run through a woolen cloth. For brown bookbinders' varnish, or a colorless varnish for maps, photographs, etc., the solution has to boil for about an hour longer, but only simmering, and then to cool very slowly without stirring; better let it stand over night, and let the fire go out under it. In the morning a wax-like substance will be found on the surface of the solution, and the other impurities of the shellac as a deposit on the bottom of the vessel. The solution is likewise to be run through a woolen cloth and then to be filtered. (*See No.* 2934.) To make a transparent brown varnish—bookbinders' varnish—this filtered solution has to be precipitated with diluted sulphuric acid (1 part acid to 20 parts water), the precipitate collected on a coarse muslin cloth, and washed out with cold clear water till it runs through without taste. (*See No.* 24.) Then fill a stone or wooden vessel with boiling water, and throw the precipitate in it; it will directly soften and stick together; this half mass has to be kneaded in the hands, doubled up, melted, and drawn out till it assumes a fine silky lustre, then drawn out to the desired thickness in sticks, like candy, and it is then ready for solution. To make the BOOKBINDERS' VARNISH, dissolve 1 part of the precipitate in 2½ parts 95 per cent. alcohol. To make the COLORLESS VARNISH, dissolve 1 part of the precipitate in the same quantity of alcohol. Add 1½ drachms oil of lavender to each pint. The colorless varnish will look like whey, but more transparent.

2934. Filter for Shellac. To make a filter for shellac, take a small wooden keg, remove the top and bottom, and fasten to one side a piece of muslin; on the muslin bring about 4 inches fine, washed sand, and on top of the sand a layer of clean straw; then pour the solution into the filter and let it run through. Should the first portion run through be not perfectly clear, like red French wine, it has to be brought back to the filter. When nothing more will run through, pour some clean water on the filter to wash the remaining solution out.

2935. French Transparent Colorless Varnish. To make white French transparent colorless varnish for maps, the solution (*see No.* 2933) has to be bleached. The bleaching fluid is made as follows, and the proportions are for 1 pound of shellac: Take 1 pound good English chloride of lime, dissolve it in 14 pounds cold water, triturating the lumps well; let it subside, and decant the clear fluid; add 7 pounds of water to the residue, and, when subsided, add the clear liquor to the other; precipitate this liquor with a solution of carbonate of soda, let the carbonate of lime settle, and decant the clear chloride of soda; wash the sediment out with water, and add the clear liquid to the former, put it in a high stone jar, and give it a rotary motion with a wooden stick, pouring in at the same time very diluted sulphuric acid, till it assumes a greenish color and a smell of chlorine is perceptible. Then add some of this liquid to the solution to be bleached, under constant stirring, till all the color is gone. French polish will look like milk. Then precipitate with dilute sulphuric acid, exactly as the solution for bookbinders' varnish, and treat the precipitate in the same manner, in hot water. (*See No.* 2933.) All iron must be carefully avoided as soon as the chlorine liquor is added. Dissolve 1 pint of the above in 3 pints of 95 per cent. alcohol, and do not add any oil of lavender, as in No. 2933. For photographs this solution is too strong; 1 part of bleached shellac to 6 parts alcohol will answer. For maps the solution should not be applied immediately to the paper, but the latter should first receive a coat of boiled and strained starch.

2936. Wax Varnish, or Milk of Wax. Pure white wax, 1 pound; melt with as gentle a heat as possible, and warm spirit of wine (90 per cent.), 1 pint; mix perfectly, and pour the liquid out upon a cold porphyry slab; next grind it with a muller to a perfectly smooth paste, with the addition of more spirit as required; put the paste into a marble mortar, make an emulsion with 3½ pints gradually added, and strain through muslin. Used as a varnish for paintings; when dry, a hot iron is passed over it, or heat is otherwise evenly applied, so as to fuse it, and render it transparent; when quite cold it is polished with a clean linen cloth. The most protective of all varnishes. Many ancient paintings owe their freshness at the present day to this varnish.

2937. Wax Varnish for Furniture. Wax, 3 ounces; oil of turpentine, 1 quart; dissolve by a gentle heat. Used for furniture.

2938. Varnish for Paper Hangings, Maps, Prints, &c. Take of genuine pale Canada balsam and rectified oil of turpentine, equal parts, and mix thoroughly. Give the articles 2 coats of size before varnishing.

2939. Varnish for Card-Work, Baskets, &c. Take black, red, or any other colored sealing-wax, according to fancy; break it into small pieces, and add enough rectified or methylated spirit to cover it; let the vessel stand near the fire for 2 days until it is quite dissolved. Give the article 2 coats of size before varnishing. The size is made by dissolving parchment cuttings in boiling water. This is a most useful varnish for fret-work, card-work, baskets, &c.

2940. Water Lac Varnish. Pale shellac, 5 ounces; borax, 1 ounce; water, 1 pint; digest at nearly the boiling point, until dissolved; then strain. Equal to the more costly spirit varnish for many purposes; it is an excellent vehicle for water colors, inks, &c.; when dry it is waterproof.

2941. Transparent Green Varnish. A beautifully transparent green varnish is made by taking a small quantity of "Chinese blue," with about twice the amount of finely powdered chromate of potash, and stirring these in copal varnish thinned with turpentine. A thorough grinding of this mixture must be made for the purpose of intimately incorporating the ingredients, as otherwise it will not be transparent. A preponderance of chromate of potash gives a yellowish shade to the green, and a deficiency increases the amount of blue. This varnish, thus colored, produces a very striking effect in japanned goods, paper-hangings, etc., and can be made very cheaply.

2942. Aniline Transparent Varnishes. The aniline colors are particularly well adapted for the manufacture of transparent lacs, which possess great intensity even in very thin films, and are hence very suitable for coloring glass or mica. The process recommended by F. Springmuhl is to prepare separately an alcoholic solution of bleached shellac or sandarach, and a concentrated alcoholic solution of the coloring matter, which last is added to the lac before using it; the glass or mica to be coated being slightly warmed. Colored films of great beauty may also be obtained, according to Springmuhl, from colored solutions of gun cotton in ether, the coloring matter being here dissolved in alcohol and ether. The collodion film has its elasticity greatly increased by the addition of some turpentine oil; and when applied cold, can be removed entire. The colored films may now be cut into any pattern, and again attached to transparent objects.

2943. Aniline Black Varnish. An aniline black varnish, of recent Parisian production, is the following: Dissolve 6¾ drachms avoirdupois of aniline blue, 1½ drachms of fuchsine, and 4½ drachms of naphthaline yellow, in 1 quart alcohol. The whole is dissolved by agitation in less than 12 hours. One application renders an object ebony black; the varnish can be filtered, and will never deposit afterwards.

2944. Transparent Varnish for Prints and Pictures. Dilute ¼ pound Venice turpentine with a gill, or thereabouts, of spirits of wine. If too thick, a little more of the latter; if not enough, a little more of the former; so that it is brought to the consistence of milk. Lay 1 coat of this on the right side of the print, and, when dry, it will shine like glass. If it is not satisfactory, lay on another coat.

2945. To Make the Design of a Print Appear in Gold. After having laid on both sides of the print one coat of the varnish described in No. 2944, in order to make it transparent, let it dry a little while; then, before it is quite dry, lay some gold in leaves on the wrong side of the print, pressing it gently on with a cotton pad. By these means, all parts where these leaves have been laid will appear like massive gold on the right side. When this is all thoroughly dry, lay on the right side of it one coat of the varnish described above, and it will then be as good as any crown glass. A pasteboard may be put behind the print, to support it better in its frame.

2946. Clear Gutta-Percha Solution. Cut gutta-percha into thin strips and put it in a glass bottle, and add as much chloroform as makes a thick paste. This paste is then placed in very hot water, and kneaded with the fingers. After considerable manipulation the gutta-percha loses much of its color, and if this process is repeated, becomes very nearly colorless, having only a pale straw tint. A chloroform solution may then be made of any strength, which is useful for many purposes—when thin, as a substitute for court plaster, and when thick, as a stopping for decayed teeth.

2947. Solvents for India-Rubber and Gutta-Percha to Make Flexible Varnish. Rubber does not dissolve easily enough to give a varnish by simply placing it in a bottle with the solvent. Sulphuric ether is one of its regular solvents, but then it must be pure rectified ether, and not the mixture of ether and alcohol which is sold for ether in many drug stores. It also must be pure rubber, and not the sulphur-vulcanized article. The pure rubber must be cut into small pieces, soaked in the ether in a warm place for about 24 hours until they are swollen up, and then it must be kneaded in a mortar. In such a way rubber varnishes may be made even with common benzine. When treated with hot benzole (from coal tar, not benzine from petroleum), it swells to 30 times its former bulk; and if then triturated with a pestle, and pressed through a sieve, it affords a homogeneous varnish, which being applied by a flat edge of metal or wood to cloth, prepares it for forming waterproof cloth. Chloroform and the bisulphuret of carbon dissolve India-rubber and gutta-percha in the cold. Turpentine disintegrates and dissolves India-rubber and gutta-percha when hot. The fixed oils also readily dissolve them with the aid of heat. When India-rubber remains sticky after working it, it is a proof that the temperature was too high, or that too much turpentine was used in the solutions or varnishes; turpentine rubber varnish has naturally a tendency to dry sticky; benzole or the fixed oils are better. (*See No.* 2248.)

2948. Flexible Varnish for Balloons, etc. Digest cold, 1½ ounces India-rubber, cut small, in 1 pint of either chloroform, sulphuric ether (washed), or bisulphuret of carbon. This dries as soon as laid on.

2949. India-Rubber Varnish. Digest in a closed vessel, at a gentle heat, 1 ounce India-rubber shavings in 1 pint of rectified mineral naphtha, or benzole; then strain it. This dries very badly, and never gets perfectly hard.

2950. Tough India-Rubber Varnish. Dissolve by heat 1 ounce India-rubber in 1 quart of drying oil. This dries very tough in about 48 hours.

2951. Flexible Varnish. Boil 3 ounces dried white copperas, 3 ounces sugar of lead, and 8 ounces litharge, in 1 gallon linseed oil; stir constantly until it strings well, then cool slowly and decant the clear portion. If too thick, thin with quick-drying linseed oil.

2952. Colpin's India-Rubber Varnish. India-rubber in small pieces, washed and dried, are fused for 3 hours in a close vessel, on a gradually heated sand-bath. On removing from the sand-bath, open the vessel and stir for 10 minutes, then close again, and repeat the fusion on the following day, until small globules appear on the surface. Then strain through a wire sieve.

2953. Metallic Varnish, or Varnisher's Amalgam. Melt 4 ounces grain tin (*see Index*) with 1 ounce bismuth; add 1 ounce quicksilver, and stir till cold; then grind it very fine with white of egg or varnish, and apply this metallic varnish to the figure to be coated.

2954. Varnish for Gun Barrels. The varnish used for gun barrels, after they are bronzed, is made by dissolving 1 ounce of shellac and 1 or 2 drachms of dragon's blood in a quart of alcohol, and filtering the solution through blotting paper into a bottle, which must be kept closely corked. This varnish, being laid on the barrel, and become perfectly dry, must be rubbed with a burnisher to render it smooth and glossy.

2955. Submarine Varnish. Resin, 2 parts; galipot, 2 parts; essence of turpentine, 40 parts. Melt the above, and add, in the form of very fine powder, and well mixed, sulphide of copper, 18 parts; regulus of antimony, 2 parts. This varnish is said to protect wood from worms, and to prevent the adherence of barnacles and parasites to the bottom of ships. It also preserves iron from oxidation.

2956. Varnish for Iron. The following is a method given by M. Weiszkopf, of producing upon iron a durable black shining varnish: Take oil of turpentine, add to it, drop by drop, and while stirring, strong sulphuric acid, until a syrupy precipitate is quite formed, and no more of it is produced on further addition of a drop of acid. The liquid is now repeatedly washed away with water, every time renewed after a good stirring, until the water does not exhibit any more acid reaction on being tested with blue litmus paper. The precipitate is next brought upon a cloth filter, and, after all the water has run off, the syrupy mass is fit for use. This thickish deposit is painted over the iron with a brush; if it happens to be too stiff, it is previously diluted with some oil of turpentine. Immediately after the iron has been so painted, the paint is burnt in by a gentle heat, and, after cooling, the black surface is rubbed over with a piece of woolen stuff dipped in, and moistened with linseed oil. According to Weiszkopf, this varnish is not a simple covering of the surface, but it is chemically combined with the metal, and does not, therefore, wear or peel off the iron, as is the case with other paints and varnishes.

2957. Brilliant French Varnish for Boots and Shoes. Take ¾ of a pint spirits of wine; 5 pints white wine; ½ pound powdered gum senegal; 6 ounces loaf sugar; 2 ounces powdered galls; 4 ounces green copperas. Dissolve the sugar and gum in the wine. When dissolved, strain; then put it on a slow fire, being careful not to let it boil. In this state put in the galls, copperas, and the alcohol, stirring it well for five minutes. Then remove from the fire, and, when nearly cool, strain through flannel, and bottle for use. It is applied with a pencil brush. If not sufficiently black, a little sulphate of iron, and half a pint of a strong decoction of logwood, may be added, with $\frac{1}{16}$ ounce pearlash.

2958. Varnish for Fastening the Leather on Top Rollers in Factories. Dissolve 2½ ounces of gum-arabic in water and a like amount of isinglass dissolved in brandy, and it is fit for use.

2959. Varnish for Engraving on Glass. Wax, 1 ounce; mastich, ½ ounce; asphaltum, ¼ ounce; turpentine, ½ drachm.

2960. Etching Varnishes. White wax, 2 ounces; asphaltum, 2 ounces. Melt the wax in a clean pipkin, add the asphaltum in powder, and boil to a proper consistence. Pour it into warm water, and form it into balls, which must be kneaded, and put into taffeta for use. Or: white wax, 2 ounces; Burgundy pitch, ½ ounce; black pitch, ½ ounce. Melt together, and add by degrees 2 ounces powdered asphaltum, and boil it till a drop cooled on a plate becomes brittle.

2961. Etching Fluid for Copper. Aquafortis, 2 ounces; water, 5 ounces. Mix.

2962. Callot's Eau Forte for Fine Touches. Dissolve 4 parts each of verdigris, alum, sea salt, and sal ammoniac, in 8 parts vinegar; add 16 parts water, boil for a minute, and let it cool.

2963. Etching Fluid for Steel. Iodine, 1 ounce; iron filings, ¼ drachm; water, 4 ounces. Digest till the iron is dissolved. Or: pyroligneous acid, 4 parts by measure; alcohol, 1 part. Mix, and add 1 part double aquafortis (specific gravity 1.28). Apply it from 1½ to 15 minutes.

2964. To Make Colored Prints Resemble Oil Paintings. Take of Canada balsam, 1 ounce; spirit of turpentine, 2 ounces; mix them together. Before this composition is applied, the drawing or print should be sized with a solution of isinglass in water, and, when dry, the varnish should be applied with a camel's-hair brush.

2965. To Varnish Drawings, or any Kind of Paper or Card Work. Dissolve 1 ounce best isinglass in about 1 pint water, by simmering it over the fire; strain it through fine muslin, and keep it for use. Try the size on a piece of paper moderately warm. If it glistens, it is too thick, and requires more water; if it soaks into the paper, it is too thin, and needs more isinglass; it should merely dull the surface. Then give the drawing 2 or 3 coats, letting it dry between each, being careful (particularly in the first coat) to bear very lightly on the brush (which should be a flat camel's-hair), from which the size should flow freely; otherwise, the drawing may be damaged. Then take the best mastich varnish, and with it give at least 3 coats. This is the method used by many eminent artists, and is found superior to any that has been tried.

2966. Varnish for Shoes. Put ½ pound gum shellac, broken up in small pieces, into a quart bottle or jug, cover it with alcohol, cork it tight, and put it on a shelf in a warm place; shake it well several times a day, then add a piece of camphor as large as a hen's egg, shake it well, and in a few hours shake it again and add 1 ounce lampblack. If the alcohol is good it will all be dissolved in 2 days; then shake and use. If it gets too thick, add alcohol, pour out 2 or 3 tea-spoonfuls in a saucer, and apply it with a small paint brush. If the materials are all good it will dry in about 5 minutes, giving a gloss equal to patent leather, and will be removed only by wearing it off. The advantage of this preparation over others is, it does not strike into the leather and make it hard, but remains on the surface, and yet excludes the water almost perfectly. The same preparation is admirable for harness, and does not soil when touched, as is usually the case with lampblack preparations.

2967. Varnish for Harness. Take 95 per cent. alcohol, 1 gallon; white pine turpentine, 1½ pounds; gum shellac, 1½ pounds; Venice turpentine, 1 gill. Let these stand in a jug in the sun or by a stove until the gums are dissolved, then add sweet oil, 1 gill; and lampblack, 2 ounces; rub the lampblack first with a little of the varnish. This varnish is better than the old style, from the fact that its polish is as good, and it does not crack when the harness is twisted or knocked about.

2968. Flexible Japan Black for Leather. Burnt umber, 8 ounces; true asphaltum, 3 or 4 ounces; boiled linseed oil, 1 gallon; grind the umber with a little of the oil; add it to the asphaltum, previously dissolved in a small quantity of the oil by heat; mix, add the remainder of the oil; boil, cool, and thin with a sufficient quantity of oil of turpentine.

2969. Inflexible Japan Black for Leather. Shellac, 1 ounce; wood naphtha, 4 ounces; lampblack to color; dissolve.

2970. Varnish or Enamel for Coating the Insides of Casks. A new application of charcoal has recently been made in England for the manufacture of a permanent enamel, or varnish for coating the insides of casks. The charcoal, which is made from the wood of Salix Alba (white willow), is reduced to a very fine powder, and mixed with proper proportions of shellac and methylated spirit. When ready for use it is laid on with a brush, and the inside of the cask is fired, so as to remove the spirit and leave only the lining of charcoal and shellac; it is then coated again and fired a second time, after which it is allowed to stand a short time before being used. This composition is said to form a perfect enamel, and, while it prevents any chance of leakage, it preserves the casks in an extraordinary manner. It answers admirably for beer and acids, and is largely adopted by some of our principal brewers.

Varnishing.

The art of applying varnishes to various surfaces. This requires experience and care, both in the selection of appropriate varnishes, and in the manner of applying them.

2972. To Finish Walnut Wood for Varnishing. Mix, with good whiting, such colors as will produce as near as possible the color of the wood to be filled. This mixture to be dry. Then give the wood a good coat of oil, and sprinkle the mixture over the work until it is pretty well covered; then, with a soft rag or other soft substance, rub this in well. Wipe off all superfluous material. Let dry thoroughly, and varnish. This mode is far superior to sizing.

2973. Finishing Walnut. For filling walnut wood, there are many compounds in use, several of them under patents, that which discolors the wood the least, and at the same time produces a fine finish, is the most simple of them all, being nothing but fine rye flour mixed with boiled oil, Japan and turpentine, ground fine in a paint mill, and slightly colored with burnt umber.

2974. To Varnish Walnut Furniture. In dressing over old furniture, the first thing to be done is to wash it over with lime, or soda and water, to remove all effects of grease from sweaty hands, which will prevent varnish from flowing freely or hardening well. If the work requires refilling, rye flour, wheat flour, corn starch, or Paris white, ground fine in oil and turpentine, will do; but 1 or 2 coats of shellac should be laid on and rubbed smooth before applying the varnish. Work finished in oil, without varnish, should be filled with a harder substance than starch. Some use white wax reduced in turpentine; but what is better is a compound of equal parts, by weight, of whiting, plaster of Paris, pumice stone, and litharge, to which may be added a little French yellow, asphaltum, vandyke brown, and terra di Sienna. Mix with 1 part Japan, 2 of boiled oil, and 3 of turpentine. Grind fine in a mill. Lay the filling on with a brush, rub it in well, let it set 20 minutes, then rub off clean. Let it harden 2 or 3 days, then rub smooth, and, if required, repeat the process. When the filling is satisfactory, finish with linseed oil, put on with a brush; wipe off, and rub to a polish with fine cotton; finish with a silk handkerchief, or any fine fabric. When the furniture is cleaned and filled, proceed as directed in the next receipt.

2975. To Varnish Furniture. When the work is quite clean, fill up all knots or blemishes with cement of the same color. See that the brush is clean, and free from loose hairs; then dip it in the varnish, stroke it along the wire raised across the top of the varnish pot, and give the work a thin and regular coat. This must be done as quickly as possible; and yet not quickly enough to cause the varnish to foam or bubble as it leaves the brush, always taking care not to pass the brush twice over the same place, if it can possibly be avoided. Let it stand to dry in a moderately warm place, that the varnish may not chill. Varnish must always be applied in a moderately warm room, where the air is dry and free from dust; and care must be taken never to apply a second coat until the former one has become quite dry. It requires practice to find out how much varnish to take in the brush. Enough must be left on an upright surface to ensure a perfect coating; but too much will settle downwards before it sets and make unsightly ridges as it dries. On a horizontal surface, a trifle more varnish can be applied than on an upright one, but not much more; as a too thick coating, even if it cannot run, will dry neither hard nor smooth. After giving the work about 6 or 7 coats, let it get quite hard (which you will prove by pressing your knuckles on it; if it leave a mark, it is not hard enough); then, with the first three fingers of the hand, rub the varnish until it chafes, and proceed over that part of the work you mean to polish, in order to take out all the streaks or partial lumps made by the brush; then give it another coat, and let it stand a day or two to harden. The best vessel for holding varnish is sold at color shops, called a varnish pan. It is constructed of tin, with a false bottom; the interval between the two bottoms is filled with sand, which, being heated over the fire, keeps the varnish fluid, and it flows more readily from the brush. There is a tin handle to it, and the false bottom slopes from one end to the other, which causes the varnish to run to one end. It has also a wire fixed across the top, to wipe the brush against.

2976. To Polish Varnished Surfaces. To give the highest degree of lustre to varnish after it is laid on, as well as to remove the marks of the brush, it undergoes the operation of polishing. This is performed by first rubbing it with very finely powdered pumice stone and water; afterwards, patiently, with an oiled rag and Tripoli until the required polish is produced. The surface is then cleaned off with soft linen cloths, cleared of all greasiness with powdered starch, and then rubbed bright with the palm of the hand.

2977. To Keep Brushes in Order. The brushes used for varnishing are either flat in tin, or round, tied firm to the handle, and made either of camel's-hair or very fine bristles. Oil varnishes are applied with brushes of fine bristles; lac varnishes are flowed on with camel's-hair brushes. It is necessary to be very careful in cleaning them after being used; for, if laid by with the varnish in them, they are soon spoiled. Therefore, after using, wash them well in spirits of wine or turpentine, according to the nature of the varnish; after which they may be washed out with hot water and soap, when they will be as good as new, and last a great while with care. The spirits that are used for cleaning may be used to mix with varnish for the more common purposes, or the brushes may be cleaned merely with boiling water containing a little washing soda, and strong yellow soap.

2978. To Restore Furniture. An experienced cabinet-maker informs us that the best preparation for cleaning picture frames and restoring furniture, especially that somewhat marred or scratched, is a mixture of three parts of linseed oil and one part spirits of turpentine. It not only covers the disfigured surface, but restores wood to its original color, and leaves a lustre upon the surface. Put on with a woolen cloth, and when dry, rub with woolen.

Polishing.

The beauty of cabinet-work depends upon the care with which it is finished. Some clean off with scraping and rubbing with glass paper. This should be done in all cases; but it is not enough, particularly where the grain is at all soft. A good glass-paper also is essential. (*See No.* 1931.) A polish should then be added. But, unless the varnish for cabinet-work be very clear and bright, it will give a dingy shade to all light-colored woods. This should, therefore, be a previous care. Again, some workmen polish with rotten stone, others with putty-powder, and others with common whiting and water; but Tripoli will be found to answer the best.

2980. To Polish Varnish is certainly a tedious process, and considered by many as a matter of difficulty. Put 2 ounces powdered Tripoli into an earthen pot or basin, with water sufficient to cover it; then, with a piece of fine flannel four times doubled, laid over a piece of cork rubber, proceed to polish the varnish, always wetting it well with the Tripoli and water. It will be known when the process is complete by wiping a part of the work with a sponge, and observing whether there is a fair and even gloss. Clean off with a bit of mutton-suet and fine flour. Be careful not to rub the work too hard, or longer than is necessary to make the face perfectly smooth and even.

2981. The French Method of Polishing. With a piece of fine pumice-stone, and water, pass regularly over the work with the grain until the rising of the grain is down; then, with powdered Tripoli and boiled linseed oil, polish the work to a bright face. This will be a very superior polish, but it requires considerable time.

2982. To Polish Brass Ornaments Inlaid in Wood. The brass-work must first be filed very even with a smooth file; then, having mixed some very finely powdered Tripoli with linseed oil, polish the work with a rubber made from a piece of old hat or felt, as you would polish varnish, until the desired effect is produced. If the work be ebony, or black rosewood, take some elder-coal, powdered very fine, and apply it dry after you have done with the Tripoli. It will increase the beauty of the polish.

2983. To Clean Soft Mahogany or other Porous Wood. After scraping and sand-papering in the usual manner, take a sponge and well wet the surface, to raise the grain; then, with a piece of fine pumice-stone, free from stony particles, and cut the way of the fibres, rub the wood in the direction of the grain, keeping it moist with water. Let the work dry; then wet it again, and the grain will be much smoother, and will not raise so much. Repeat the process, and the surface will become perfectly smooth, and the texture of the wood much hardened. If this does not succeed to satisfaction, the surface may be improved by using the pumice-stone with cold-drawn linseed oil, proceeding in the same manner as with water. This will be found to give a most beautiful as well as a durable face to the work, which may then be polished or varnished.

2984. To Clean and Finish Mahogany Work. Scrape and sand-paper the work as smooth as possible; go over every part with a brush dipped in furniture oil, and let it remain all night; have ready the powder of the finest red brick, which tie up in a cotton stocking, and sift equally over the work the next morning, and, with a leaden or iron weight in a piece of carpet, rub it well the way of the grain, backward and forward, till it has a good gloss. If not sufficient, or if the grain appears at all rough, repeat the process. Be careful not to put too much of the brick-dust, as it should not be rubbed dry, but rather as a paste upon the cloth. When the surface is perfectly smooth, clean it off with a rubber of carpet and fine mahogany saw-dust. This process will give a good gloss, and make a surface that will improve by wear.

2985. To Clean and Polish Old Furniture. Take a quart of stale beer or vinegar, put a handful of common salt and a table-spoonful of muriatic acid into it, and boil it for 15 minutes; it may be kept in a bottle, and warmed when wanted for use. Having previously washed the furniture with soft hot water, to get the dirt off, wash it carefully with the above mixture; then polish, according to the directions, with any of the foregoing polishes.

2986. Mixture for Cleaning Furniture. Cold-drawn linseed oil, 1 quart; spirit of wine, and vinegar, ½ pint each; butter (terchloride) of antimony, 2 ounces; spirit of turpentine, ½ pint. This mixture requires to be well shaken before it is used. A little of it is then to be poured upon a rubber, which must be well applied to the surface of the furniture; several applications will be necessary for new furniture, or for such as had previously been French polished or rubbed with bees' wax.

2987. Furniture Polish. Dissolve 4 ounces best shellac in 2 pints 95 per cent. alcohol; add to this 2 pints linseed oil, and 1 pint spirits of turpentine; when mixed, add 4 ounces sulphuric ether, and 4 ounces ammonia water; mix thoroughly. Shake when used, and apply with a sponge lightly. This is an excellent article, especially where the varnish has become old and tarnished.

2988. Polishing Paste. Take 3 ounces white wax, ½ ounce Castile soap, 1 gill turpentine. Shave the wax and soap very fine and put the wax to the turpentine; let it stand 24 hours; then boil the soap in 1 gill water, and add to the wax and turpentine. This has been highly recommended.

2989. Furniture Polish. Bees' wax, ½ pound; alkanet root, ½ ounce; melt together in a pipkin until the former is well colored. Then add linseed oil, and spirits of turpentine, of each ¼ gill; strain through a piece of coarse muslin.

2990. Furniture Paste. Turpentine, 1 pint; alkanet root, ½ ounce; digest until sufficiently colored, then add bees' wax, scraped small, 4 ounces; put the vessel into hot water and stir until dissolved. If wanted pale, the alkanet may be omitted.

2991. Composition for Soft or Light Mahogany. Boil together cold-drawn linseed oil, and as much alkanet root as it will cover, and to every pint of oil add 1 ounce of the best rose pink. When all the color is extracted, strain it off, and to every pint add ½ gill spirits of turpentine. This will be a very superior composition for soft and light mahogany.

2992. To Wax Furniture. In waxing, it is of great importance to make the coating as thin as possible, in order that the veins of the wood may be distinctly seen. The following preparation is the best for performing this operation: Put 2 ounces white and yellow wax over a moderate fire, in a very clean vessel, and, when it is quite melted, add 4 ounces best spirits of turpentine. Stir the whole until it is entirely cool, and you will have a pomade fit for waxing furniture, which must be rubbed over it according to the usual method. The oil soon penetrates the pores of the wood, brings out the color of it, causes the wax to adhere better, and produces a lustre equal to that of varnish, without being subject to any of its inconveniences. The polish may be renewed at any time by rubbing it with a piece of *fine* cork.

French Polishing.

The method of varnishing furniture by means of rubbing it on the surface of the wood, is of comparatively modern date. To put on a hard face, which shall not be so liable to scratch as varnish, and yet appear equally fine, the French polish was introduced. Below we give a full direction of the process, and also the various preparations of the different compositions necessary.

2994. To French Polish. The varnish being prepared (shellac), the article to be polished being finished off as smoothly as possible with glass paper, and the rubber being made as directed below, proceed to the operation as follows:—The varnish, in a narrow-necked bottle, is to be applied to the middle of the flat face of the rubber, by laying the rubber on the mouth of the bottle and shaking up the varnish once, as by this means the rubber will imbibe the proper quantity to varnish a considerable extent of surface. The rubber is then to be enclosed in a soft linen cloth, doubled, the rest of the cloth being gathered up at the back of the rubber to form a handle. Moisten the face of the linen with a little raw linseed oil, applied with the finger to the *middle* of it. Place the work opposite the light, pass the rubber quickly and lightly over its surface uniformly in small circular strokes, until the varnish becomes dry, or nearly so; again charge the rubber as before with varnish (omitting the oil), and repeat the rubbing, until three coats are laid on, when a little oil may be applied to the rubber, and two coats more given to it. Proceed in this way until the varnish has acquired some thickness; then wet the inside of the linen cloth, before applying the varnish, with alcohol, or wood naphtha, and rub quickly, lightly, and uniformly, the whole surface. Lastly, wet the linen cloth with a little oil and alcohol without varnish, and rub as before till dry. Each coat is to be rubbed until the rag appears dry; and too much varnish must not be put on the rag at a time. Be also very particular in letting the rags be very clean and soft, as the polish depends, in a great measure, on the care taken in keeping it clean and free from dust during the operation. If the work be porous, or the grain coarse, it will be necessary to give it a coat of clear size previous to commencing with the polish; and, when dry, gently go over it with very fine glass paper. The size will fill up the pores, and prevent the waste of the polish, by being absorbed into the wood, and be also a saving of considerable time in the operation.

2995. To Make a French Polish Rubber. Roll up a strip of thick woolen cloth which has been torn off, so as to form a soft elastic edge. It should form a coil, from 1 to 3 inches in diameter, according to the size of the work. This rubber is to be securely bound with thread, to prevent it from uncoiling when it is used.

2996. Best French Polish. Shellac, 3 parts; gum mastich, 1 part; gum sandarach, 1 part; spirits of wine, 40 parts; the mastich and sandarach must first be dissolved in the spirits of wine, and then the shellac; the process may be performed by putting them into a bottle loosely corked, and placing it in a vessel of water heated to a little below 173° Fahr., or the boiling point of spirits of wine, until the solution be effected; the clear solution may be poured off into another bottle for use. Various receipts for the French polish have been published, in which ingredients are inserted that are insoluble in spirits of wine, and therefore useless; and others contain ingredients that are soluble in water, so as to render the mixture more easily injured.

2997. Common French Polish. A solution of shellac in wood naphtha, (pyroxilic spirit). (*See No.* 2999.)

2998. **Mastich French Polish.** Pale shellac, 3 pounds; mastich, 6 ounces; 90 per cent alcohol, 3 quarts. (*See next receipt.*)

2999. **Sandarach French Polish.** Shellac, 2 pounds; mastich and sandarach (both in powder), of each 1 ounce; copal varnish, 12 ounces; alcohol, 1 gallon. All the above are made in the cold by frequently stirring or shaking the ingredients together in a well-closed bottle or other vessel. French polish is used without filtering.

3000. True French Polish. To 1 pint spirits of wine add ¼ ounce each gum copal and sandarach, and 1 ounce shellac. Let the gums be well bruised, and sifted through a piece of muslin. Put the spirits and the gums together in a vessel that can be closely corked; place them near a warm stove, and frequently shake them. In 2 or 3 days they will be dissolved. Strain the mixture through a piece of muslin, and keep it tight corked for use.

3001. French Polish. To 1 pint spirits of wine add ½ ounce gum shellac, the same quantity gum lac, and ¼ ounce gum sandarach; put these ingredients into a stone bottle near a fire, frequently shaking it; when the various gums are dissolved it is fit for use.

3002. French Polish. Take 2 ounces wood naphtha, ½ ounce best shellac, 1 drachm gum benzoin; crush the gums, mix them with the naphtha in a bottle; shake them frequently till dissolved; it is then ready for use. This is the clear polish. Take a little cotton wool, apply a little of the polish to it, cover it tightly with a linen rag, to which apply a drop of linseed oil, to prevent it from sticking to the wood; use your rubber gently, polishing from a centre in a circular manner; finish with a drop of spirits of wine on a clean rubber, which will extract the oil.

3003. To Stain or Color French Polish. Wood may be stained or grained any color or design, by mixing it with the polish, or dipping the rubber in the color (finely powdered), at the time you apply the polish. (*See No.* 3002.) To produce a red, dip the cotton into dragon's blood (finely powdered), immediately applying the polish; then cover with the linen, and polish. For yellow, use the best chrome yellow. For blue, ultramarine blue, or indigo. For black, ivory or lampblack, &c. Graining is produced by touching or streaking the wood with the color, as above, in irregular lines or marks, and in such shapes as the fancy may suggest, then finishing it with a coat of clear polish.

3004. Water-Proof Polish. Take 1 pint spirits of wine, 2 ounces gum-benzoin, ¼ ounce gum sandarach, and ¼ ounce gum animo; these must be put into a stoppered bottle, and placed either in a sand-bath or in hot water till dissolved; then strain the mixture, and, after adding about ½ gill best clear poppy oil, shake it well up, and put it by for use.

3005. Bright Polish. 1 pint spirits of wine to 2 ounces gum benzoin and ½ ounce gum-sandarach, put in a glass bottle corked, and placed in a sand-bath or hot water until you find all the gum dissolved, will make a beautiful clear polish for Tunbridgeware goods, tea-caddies, &c. It must be shaken from time to time, and, when all dissolved, strained through a fine muslin sieve, and bottled for use.

3006. Prepared Spirits for Finishing Polish. This preparation is useful for finishing after any of the foregoing receipts, as it adds to the lustre and durability, as well as removing every defect, of the other polishes; and it gives the surface a most brilliant appearance. Take ½ pint best rectified spirits of wine, 2 drachms shellac, and 2 drachms gum-benzoin. Put these ingredients in a bottle, and keep it in a warm place till the gum is all dissolved, shaking it frequently; when cold, add 2 tea-spoonfuls of the best clear white poppy oil; shake them well together, and it is fit for use. This preparation is used in the same manner as the foregoing polishes; but, in order to remove all dull places, the pressure in rubbing may be increased.

3007. Strong Polish. To be used in the carved parts of cabinet-work with a brush, as in standards, pillars, claws, &c. Dissolve 2 ounces seed lac and 2 ounces white resin in 1 pint spirits of wine. This varnish or polish must be laid on warm, and if the work can be warmed also, it will be so much the better; at any rate, moisture and dampness must be avoided.

3008. How to Give Black Walnut a Dark Dead Smooth Surface. Take asphaltum, pulverize it, place it in a jar or bottle, pour over it about twice its bulk of turpentine or benzole, put it in a warm place, and shake it from time to time. When dissolved, strain it and apply it to the wood with a cloth or stiff brush. If it should make too dark a stain, thin it with turpentine or benzole. This will dry in a few hours. If it is desired to bring out the grain still more, apply a mixture of boiled oil and turpentine; this is better than oil alone. Put no oil with the asphaltum mixture, as it will dry very slowly. When the oil is dry the wood can be polished with the following: Shellac varnish, of the usual consistency, 2 parts; boiled oil, 1 part. Shake it well before using. Apply it to the wood by putting a few drops on a cloth and rubbing briskly on the wood for a few moments. This polish works well on old varnished furniture.

3009. Polish for Turners' Work. Dissolve sandarach in spirits of wine in the proportion of 1 ounce sandarach to ¼ pint of spirits; next shave bees' wax, 1 ounce, and dissolve it in a sufficient quantity of spirits of turpentine to make it into a paste; add the former mixture by degrees to it; then with a woolen cloth apply it to the work while it is in motion in the lathe, and with a soft linen rag polish it. It will appear as if highly varnished.

To Enamel Wood-Work.

This is a process for creating an artificial, glossy surface of any color on wood, very durable, and highly ornamental. It consists of three distinct, successive operations; first, the colored coating or surface; next, the preparation of the surface for polishing; and finally, polishing.

3011. To Prepare the Filling-up Color for Enameling Wood. The filling-up color, which forms the body of the enamel, is of the greatest importance to the ultimate success of the work. Of this material there are several kinds manufactured—black, brown, and yellow, for coach painters, japanners, and others; but for use in interior decoration it is preferable to use the white lead filling, as, by adding the necessary staining colors (which do not affect the properties of the enamel), a solid body of color is formed, of the same tint, or nearly so, as that with which the work is required to be finished, thus doing away with the objections which may be urged against the black or dark-colored filling. It is evident that if work which has to be finished white, or with very light tints of color, be filled up with dark-colored filling, the number of coats of paint required to obscure or kill the dark color will be so many that there will be danger of the work becoming rough and uneven in parts. The white lead should be ground stiff in turpentine, and about one-fourth part of the ordinary white lead, ground in oil added to it, in order to prevent the enamel cracking, which it has a tendency to do, except there be some little oil mixed with it. A sufficient quantity of polishing copal or best carriage varnish should now be added to bind it so that it will rub down easily, which fact cannot be properly ascertained except by actual trial, inasmuch as the drying properties of varnishes vary, and other causes influence the matter. If there be too much varnish in the stuff the work will be exceedingly difficult to cut down, and if too little, it is apt to break up in rubbing, so that it is always the safest plan to try the enamel color before commencing anything important.

3012. To Lay the Color on Enameled Wood. The color, being properly mixed, should be laid on the work in the ordinary manner, using it rather freely. It may be as well to state here that no filling should be put upon new work without the same having had 2 or 3 coats of ordinary oil paint, nor on old work without its having one coat. This gives a foundation for the filling. Successive coats of the filling should now be laid on the work until there is a sufficient thickness to cut down to a level surface. One day should intervene between each coat, in order to allow it to harden in some degree. When a sufficient number of coats are put on (which number will, of course, depend upon the state of the work to be filled up), it should stand for 2 or 3 weeks, until it is thoroughly hard; it will then be ready for cutting down, which is to be done with a felt rubber, ground pumice stone, and water.

3013. To Prepare the Rubber for Enameling Wood. The felt used should be such as the sculptors use for polishing marble, which varies in thickness from ⅛ to ¼ an inch, and about 3 inches square. This should be fastened with resinous gum to square pieces of wood of the same size, but 1 inch thick, so as to give a good hold for the hand in using. These pieces of wood, covered with felt, may be made of any size or shape to fit molded surfaces or other inequalities.

3014. To Prepare the Pumice Stone for Enameling Wood. The pumice stone to be used should be of different degrees of fineness, and should be carefully selected, so as to be sure that it is free from any gritty substance. It is sold ready ground, but in situations where it cannot be conveniently got, it may be prepared from the lump, by grinding or crushing with a stone and muller, and then passed through fine sieves or muslin; by using these of different degrees of texture the ground pumice may be produced of different degrees of fineness. Unless great care be exercised in this matter, it will be found that particles of grit will be mixed with it, which make deep scratches on the work, thus causing endless trouble and annoyance, besides spoiling the work. The greatest care is also required in keeping the felt clean and free from grit. Many workmen are careless in this matter, and, when working, set down the felt on the step-ladder or floor, thus allowing particles of sand or grit to get upon it.

3015. To Cut Down or Prepare the Surface for Polishing. In cutting down, it is best to use a piece of soft lump pumice stone to take off the rough parts. The work should then be wet with a sponge; the felt must first be soaked in water, then dipped into the powdered pumice, and the work rubbed with it, keeping it moderately wet, and rubbing with a circular motion, not straight up and down and across, and with a light touch, using only just as much pressure as will cause the pumice to bite, which will be very clearly felt while the hand is in motion. Care and patience are required to do this properly, for if the pressure be too great it forces the pumice into the body of the filling color, and scratches it instead of cutting or grinding it fairly down. No hurry will avail in doing this work, it must have its time; hurry only defeats the end in view, and often causes much unnecessary labor. A scratch, caused by want of care and too much haste, will often throw the work back for days, and involve the cost and labor of refilling. In practice the purpose is best answered by using the pumice stone, the coarser kind first, then the medium, and finishing with the finest last. It will be found advantageous to let a day elapse between the rubbing, for when the surface is cut down the filling will in all cases be softer underneath, and if it be allowed to stand for a day, the newly exposed surface gets harder, and of course rubs down better. The pumice stone should be well washed off the work occasionally, in order to see what progress is being made, and if it require more rubbing or not. If, after the first rubbing, the surface be found not sufficiently filled up, it may have one or more additional coats of filling before much labor has been spent upon it.

3016. To Polish the Filling. When sufficiently rubbed down with the pumice stone—that is to say, when it has been cut down to a fine, level, and uniform surface, (*see No.* 3015), the work should stand for a day or two to harden. It will now depend entirely upon the work, as to whether it must be polished upon the filling, or whether it will have to be varnished and polished. If the filling be of the right color, and of one uniform tint, it is best to be finished in this state, because it will have a surface and texture which cannot be got by any other means. Finished in this state it has all the uniformity of surface and evidence of finish, without that appearance of varnish which is so objectionable. After it has stood a day or two, the work must be polished in this way: Take a clean felt and rotten stone, either in oil or water, and with this rub the work as before, until the polish begins to appear; then take a boss (*i. e.* a ball of cotton wool inclosed in fine silk), put the rotten stone upon this and keep rubbing with the circular motion until the polish is uniform and equal all over. The rotten stone must now be carefully cleaned off; if it be in oil, clean off with fine flour; if in water, with sponge and wash-leather and water, taking care not to scratch. A clean damp chamois or wash-leather will now be required, which must be held in the left hand, leaving the right perfectly at liberty. Now use the ball of the right hand, press gently upon the panel, and draw it forwards or towards you. If this be done properly, it will bring up a clear polish upon the work. The hand should be kept slightly damp by drawing it across the leather almost every time the hand is drawn forward. If this be done effectually, a rustling sound will be produced while the hand is in motion; if this be so, the polish will be sure to follow. The polish thus produced on the filling alone will have a beautiful soft appearance; but if the work has to be finished with a brilliant lustre, and to a high degree of polish, proceed as follows:

3017. To Finish Wood with a Brilliant Polish. After being cut down with the pumice and felt as directed in No 3015, the filling has to be coated with two or more coats of the best polishing copal varnish, having a quantity of the best tube flake white; this should be mixed with the varnish in sufficient quantity to form a creamy mixture, with which the work must be coated—one, two, or three coats, as may be desirable. This should stand for 3 or 4 weeks, until it becomes hard; for the harder it is the better it will polish. It must then be cut down with felt and the finest ground pumice stone in water, and polished with the rotten stone, as before described. By this means a bright and brilliant polish may be obtained, of a very enduring nature. The same process will of course answer for all varnished imitations of woods and marbles, and all work which will admit of the application of oil varnishes.

Japanning is a kind of varnishing or lacquering, practiced in perfection by the Japanese, whence the name. The only difference between varnishing and japanning is that after the application of every coat of color or varnish, the object so varnished is placed in an oven or chamber called a stove, at as high a temperature as can safely be employed without injuring the articles or causing the varnish to blister or run.

3019. To Prepare Metal for Japanning. Metal requires no other preparation than cleaning with turpentine, to free it from grease or oil, unless the latter should happen to be linseed oil, in which case the cleaning is generally dispensed with, and the articles are placed in the stove and heated until the oil is baked quite hard.

3020. To Prepare Wood for Japanning. Wood that is intended to be used for the best japanned work, requires to be thoroughly dried before it is made up, otherwise it will be subject to all the evils of shrinking, warping, and splitting, when exposed to the heat of the stove. To avoid these evils, the wood, after having been well seasoned in the usual manner, by exposure to the air, is sawn out nearly to the required forms, and baked for several days in the japanner's stove, the heat of which is gradually increased; and the wood is afterwards worked up into chairs, tables, trays, and similar articles, which are afterwards again exposed to the heat of the stove, and any cracks or other imperfections, that may be thus rendered apparent, are carefully stopped with putty or white lead before the japanning is commenced.

3021. To Prepare the Ground for Japanning. For black japanned work, the ground is first prepared with a coating of black, made by mixing dross ivory black to a proper consistence with dark colored *anime* varnish, as this gives a blacker surface than could be produced by japan alone. If the surface is required to be polished, five or six coats of japan are necessary to give sufficient body to prevent the japan from being rubbed through in polishing.

3022. To Make Black Japan Varnish. Melt together 50 pounds Naples asphaltum and 8 pounds dark gum anime, and boil for 2 hours in 12 gallons linseed oil; then melt 10 pounds dark gum amber, and boil it with 2 gallons linseed oil; add this to the other, with a sufficient quantity of dryers, and boil for 2 hours longer, or until a little of the mass, when cooled, may be rolled into pills; then withdraw the heat, and afterwards thin down with 30 gallons oil of turpentine. This is excellent for either wood or metals.

3023. Flexible Black Japan Varnish. A good black japan is made of burnt umber, 4 ounces; true asphaltum, 2 ounces; and boiled oil, 2 quarts. Dissolve the asphaltum at first in a little oil, using a moderate heat; then add the umber, ground in oil, and lastly, the rest of the oil, and incorporate thoroughly. Thin with turpentine. It is a flexible japan, and may be used on metal work which requires to be bent somewhat.

3024. Colored Japan. For colored works no japan is used, but they are painted with ordinary painters' colors, ground with linseed oil or turpentine, and mixed with anime varnish; and the work is dried in the oven in the same manner as the black japan. To protect the colors, and give brilliancy and durability to the surface, the work is afterwards varnished with copal or anime varnish, made without dryers. 2 or 3 coats of varnish suffice for ordinary works, and 5 or 6 for the best works that are polished. Very pale varnish is of course required for light colors. Ornamental devices are painted on the objects in the usual manner, after the general color of the ground has been laid on. The colors are dried in the stove, and the work is finally varnished and polished just the same as plain colors, but more carefully.

3025. Transparent Japan Varnish. Oil turpentine, 8 ounces; oil lavender, 6 ounces; camphor, 1 drachm; bruised copal, 2 ounces; dissolve. Used for tin, &c. Quick drying copal varnish is usually substituted.

3026. To Color Japan Varnish. The above is a transparent japan, but by the following modifications any or all of the various colors may be made from it. It is indispensable that the colors be ground to an impalpable powder before mixing with the varnish, and should then be thoroughly ground with the varnish, otherwise it is preferable to apply the color first as a paint, and varnish afterwards with the above transparent japan. Previous to varnishing a painted surface, it should be cut down with pulverized pumice-stone, &c., as directed in No. 3015.

3027. To Color Japan Blue. Indigo and Prussian blue, both finely pulverized, of each ½ ounce; spirits of turpentine, 1 pint. Mix well and strain. Or use verditer glazed with Prussian blue or smalt; mix with the varnish in No. 3025.

3028. To Color Japan Red. Vermilion makes a fine scarlet, but its appearance in japanned work is much improved by glazing it with a thin coat of lake, or even rose pink. Or: Take spirits of turpentine, ½ pint; add cochineal, ½ ounce; let stand 15 hours, and strain. Add to the transparent varnish (*see No.* 3025) to suit the fancy.

3029. To Color Japan Yellow. King's yellow, turpeth mineral (subsulphate of mercury), and Dutch pink, all form very bright yellows, and the latter is very cheap. Seed lac varnish assimilates with yellow very well; and when they are required very bright, an improvement may be effected by infusing turmeric in the varnish which covers the ground. Or: Take 1 ounce of pulverized root of curcuma and stir of it into 1 pint of the transparent varnish (*see No.* 3025) until the color pleases you; let stand a few hours, and strain.

3030 To Color Japan Green. Distilled verdigris laid on a ground of leaf gold produces the brightest of all greens; other greens may be formed by mixing King's yellow and bright Prussian blue, or turpeth mineral and Prussian blue, or Dutch pink and verdigris. Mix with varnish. (*See Nos.* 3025 *and* 1421.)

3031. To Color Japan Orange. Mix a *little* red with yellow until the desired color is obtained; and add to transparent japan. (*See No.* 3025.)

3032. To Color Japan White. White grounds are obtained with greater difficulty than any other. One of the best is prepared by grinding up flock-white, or zinc-white, with ½ of its weight of starch, and drying it; it is then tempered, like the other colors, using the mastich varnish for common uses; and that of the best copal for the finest.

3033. To Color Japan Pink. Mix sufficient red (*see No.* 2028) with transparent varnish (*see No.* 3025) to give the desired tint of pink.

3034. To Color Japan Purple. Mix red and blue together, and add to the varnish. (*See No.* 3025.)

3035. To Color Japan Violet. A violet japan may be obtained by mixing purple (*see No.* 3034), and white (*see No.* 3032), with transparent japan (*see No.* 3025.)

3036. To Color Japan Brown. For brown japanned works, the clear japan alone is used as the ground, or umber is mixed with the japan to give the required tint, and the work is afterwards dried in the oven, in the same manner as black japan.

3037. To Japan Old Tea-Trays. First clean them thoroughly with soap and water and a little rotten-stone; then dry them by wiping and exposure at the fire. Now get some good copal varnish, mix with it some bronze powder, and apply with a brush to the denuded parts, after which set the tea-tray in an oven, at a heat of 212° to 300°, until the varnish is dry. Two coats will make it equal to new.

India Japanning.

The great peculiarity in the Indian method is the embossing, or raising the figures, &c., above the surface or ground, and the metallic or bronze-like hue of the several designs; the grotesque appearance of the several ornaments, whether figures, landscapes, or whatever other designs they are embellished with, being so totally different from every principle of perspective, and so opposite to every idea we have of correct drawing. Nothing but the study of Chinese models themselves will enable the workmen to imitate, with any degree of precision, their several characteristics.

3039. Ground for Chinese Japan. Mix any quantity of the finest whiting to the consistency of paint, with isinglass size; lay on your wood 2 or 3 coats, observing to put it on evenly and smoothly, and not too thick; let it dry; then rub it gently with a soft rag and water till the surface is quite level and polished; if a small portion of honey is added to the mixture, it will render it less liable to crack or peel off. If the ground is to be black, which is most usual, give it a coat or two of the black japan mentioned in the common method of japanning (*see No.* 3032), and it is prepared for the figures, &c.

3040. Plaster Ground for Chinese Japan. Mix fine plaster of Paris with size not too thick, and apply it quickly, for it soon gets hard. Two coats, in most instances, will be sufficient. After it *is* quite dry, polish it with fine glass paper, and rub it with a wet soft cloth; then give it 2 or 3 coats of drying linseed oil, or as much as it will soak up. When dry, it is ready for japanning.

3041. To Trace Designs on the Ground. Having drawn the figures on a piece of white paper either with ink or pencil, rub the back of it with fine chalk or whiting, and shake all the loose powder off; lay it on the ground, and trace or go over every part of the outline with the end of a blunt bodkin, or other similar instrument; you will then have a sketch in faint outline on your ground. Then proceed to put in the figures, &c., with any desired color, or bronze them.

3042. To Raise Figures on the Work. Prepare a mixture of whiting and size (some prefer the whites of eggs), of a consistency to flow freely from the pencil, the hairs of which must be rather long. Begin with a figure, or other part—but do not do too much at a time—and trace the outline correctly, with a free hand; then take a piece of stick pointed at the end, dip it into the composition, and fill up the inside of the outline. Continue to put more of the mixture on till it is raised sufficiently above the surface. Let it get quite dry, and then polish it with a small camel's-hair pencil and clean water, so as to make it perfectly smooth and level. Care must be taken in this process, that the composition is not too thin, or it will spread beyond the bounds of the outline, but just so thick as to drop from the stick. Some mix with the whiting a portion of flake-white, or dry white-lead. This is an improvement, and for very particular work should be adopted.

3043. To Japan Work-Boxes and Fancy Articles. There is a very pretty method of ornamenting boxes, cabinets, &c., so that the figures appear of the color of the wood, and the ground black or colored; this, by many, is produced by first tracing out the pattern, and then pricking in those parts which shall appear as the ground, either black or any color at fancy. This is a very tedious process, and even when finished with the greatest care, will not appear regular or well defined in the pattern. The following method will be found very expeditious, and at the same time very correct; it is but little known, and, as such, will to the practical japanner be the more acceptable. It may also be applied to many other purposes than here alluded to. The following preparation is necessary, and may be termed the stopping out mixture; it is made by dissolving the best white bees' wax in spirits of turpentine till it is of the consistency of varnish. Keep this mixture in a bottle, and, when wanted for use, mix sufficient for your present purpose with white lead in powder, or flake white, to give it a body—but not too thick, only so that it will flow freely from the brush. Having traced the design, go over those parts which are to remain of the color of the wood, and let it dry; then mix ivory-black (or other color as may be required), in very fine powder, with parchment or isinglass size, and go evenly and smoothly over every part of the work. It will now appear wholly black, or of whatever color that was mixed with the size. Let the whole get thoroughly dry; then, with a stiff brush dipped in plain spirits of turpentine, rub the whole of the work well, and those parts that have been gone over with the stopping-out mixture, will come off, leaving the black or other color perfect. It will then appear as if the work had been pricked in, but much sharper, and will, if carefully done, have a beautiful effect. You have now nothing more to do than varnish the work, as usual, and polish it as directed in Nos. 2979, &c. To finish the work in the manner of Indian japan, give it 8 or 10 coats of varnish, so that it will bear polishing.

3044. Sealing-Wax Varnish. For fancy work, this has of late years been much used, and, if well applied and the wax good, will be a very good imitation of India japan. The method of making the varnish or japan is very easy, being simply reducing the wax to a coarse powder, and pouring the best spirits of wine on it in a bottle, and letting it gradually dissolve without heat, shaking the bottle occasionally till it is all dissolved. A 2 ounce stick of the best wax will be enough for $\frac{1}{4}$ pint of spirits. Much depends on the goodness of the sealing-wax, and the color of the varnish may be varied by using differently colored wax. The finest vermilion sealing-wax makes the best varnish, the other colors not flowing quite as well; white sealing-wax is very apt to clot when drying. As this varnish dries very quickly, it should not be made until it is wanted for use.

Lacquers.

Lacquers are used upon polished metals and wood to impart the appearance of gold. As they are wanted of different depths and shades of color, it is best to keep a concentrated solution of each coloring ingredient ready, so that it may at any time be added to produce any desired tint. Lacquer should always stand till it is quite fine, before it is used.

3046. To Lacquer Brass Work. If the work is old, clean it first, according to the directions hereafter given; but if new, it will merely require to be freed from dust, and rubbed with a piece of wash-leather, to make it as bright as possible. Put the work on a hot iron plate (or upon the top of the stove), till it is moderately heated, but not too hot, or it will blister the lacquer; then, according to the color desired, take of the following preparations, and, making it warm, lay hold of the work with a pair of pincers or pliers, and with a soft brush apply the lacquer, being careful not to rub it on, but stroke the brush gently one way, and place the work on the hot plate again till the varnish is hard; but do not let it remain too long. Experience will best tell you when it should be removed. Some, indeed, do not place it on the stove or plate a second time. If it should not be quite covered, you may repeat it carefully; and, if pains be taken with the lacquer, it will look equal to metal gilt.

3047. To Clean Old Brass Work for Lacquering. Make a strong lye of wood-ashes, which may be strengthened by soap-lees; put in the brass-work, and the lacquer will soon come off; then have ready a mixture of aquafortis and water, sufficiently strong to take off the dirt; wash it afterwards in clean water, and lacquer it with such of the following compositions as may be most suitable to the work.

3048. To Make Gold Lacquer for Brass. Rectified spirits of wine, $\frac{1}{2}$ pint; mix $\frac{1}{2}$ pound of seed-lac, picked clean, and clear of all pieces (as upon that depends the beauty of the lacquer) with the spirits of wine; keep them in a warm place, and shake them repeatedly. When the seed-lac is quite dissolved, it is fit for use.

3049. Gold Lacquer. Put into a clean four gallon tin, 1 pound ground turmeric, $1\frac{1}{2}$ ounces powdered gamboge, $3\frac{1}{2}$ ounces powdered gum-sandarach, $\frac{3}{4}$ pound shellac, and 2 gallons spirits of wine. After being agitated, dissolved, and strained, add 1 pint of turpentine varnish, well mixed.

3050. Gold Colored Lacquer for Watch Keys, Etc. Seed-lac, 6 ounces; amber, 2 ounces; gamboge, 2 ounces; extract of red sandal wood in water, 24 grains; dragon's blood, 60 grains; oriental saffron, 36 grains; pounded glass, 4 ounces; pure alcohol, 36 ounces. The seed-lac, amber, gamboge, and dragon's blood must be pounded very fine on porphyry or clean marble, and mixed with the pounded glass. Over this mixture is poured the tincture formed by infusing the saffron and the extract of sandal wood in the alcohol for 24 hours. Metal articles that are to be covered with this varnish are heated, and, if they are of a kind to admit of it, are immersed in packets. The tint of the varnish may be varied in any degree required, by altering the proportions of the coloring quantities according to circumstances.

3051. Deep Gold Lacquer. Seed-lac, 3 ounces; turmeric, 1 ounce; dragon's blood, $\frac{1}{4}$ ounce; alcohol, 1 pint. Digest for a week, frequently shaking, decant and filter. Deep gold colored.

3052. Dark Gold Colored Lacquer. Strongest alcohol, 4 ounces; Spanish annotto, 8 grains; powdered turmeric, 2 drachms; red saunders, 12 grains. Infuse and add shellac, etc., as to the pale tin lacquer (*see No.* 3058), and when dissolved add 30 drops of spirits of turpentine.

3053. Gold Lacquer. Ground turmeric, 1 pound; gamboge, 1½ ounces; gum sandarach, 3½ pounds; shellac ¾ pound; all in powder; rectified spirit of wine, 2 gallons. Dissolve, strain, and add turpentine varnish, 1 pint.

3054. Brass Lacquer. Take 8 ounces shellac, 2 ounces sandarach, 2 ounces annotto, ½ ounce dragon's blood resin, 1 gallon of spirits of wine. The article to be lacquered should be heated slightly, and the lacquer applied by means of a soft camel's-hair brush.

3055. Pale Brass Lacquer. Take 2 gallons spirits of wine, 3 ounces cape aloes cut small, 1 pound fine pale shellac, 1 ounce gamboge cut small. Digest for a week, shake frequently, decant and filter.

3056. Lacquer for Bronzed Dipped Work. A lacquer for bronzed dipped work may be made thus: Alcohol, 12 gallons; seed-lac, 9 pounds; turmeric, 1 pound to the gallon; Spanish saffron, 4 ounces. The saffron may be omitted if the lacquer is to be very light.

3057. Lacquer for Tin Plate. Best alcohol, 8 ounces; turmeric, 4 drachms; hay saffron, 2 scruples; dragon's blood, 4 scruples; red saunders, 1 scruple; shellac, 1 ounce; gum sandarach, 2 drachms; gum mastich, 2 drachms; Canada balsam, 2 drachms; when dissolved, add spirits of turpentine, 80 drops.

3058. Pale Tin Lacquer. Strongest alcohol, 4 ounces; powdered turmeric, 2 drachms; hay saffron, 1 scruple; dragon's blood in powder, 2 scruples; red sanders, ½ scruple. Infuse this mixture in the cold for 48 hours, pour off the clear, and strain the rest; then add powdered shellac, ½ ounce; sandarach, 1 drachm; mastich, 1 drachm; Canada balsam, 1 drachm. Dissolve this in the cold by frequent agitation, laying the bottle on its side, to present a greater surface to the alcohol. When dissolved, add 40 drops of spirits of turpentine.

3059. Iron Lacquer. Take 12 parts amber, 12 parts turpentine, 2 parts resin, 2 parts asphaltum, 6 parts drying oil. Or, 3 pounds asphaltum, ½ pound shellac, 1 gallon turpentine.

3060. Red Lacquer. Take 2 gallons spirits of wine, 1 pound dragon's blood, 3 pounds Spanish annotto, 4½ pounds gum sandarach, 2 pints turpentine. Made as pale brass lacquer.

3061. Red Lacquer. Spanish annotto, 3 pounds; dragon's blood, 1 pound; gum sandarach, 3½ pounds; rectified spirit, 2 gallons; turpentine varnish, 1 quart. Dissolve and mix as the last.

3062. Lacquer for Philosophical Instruments. Gamboge, 1½ ounces; gum sandarach, 4 ounces; gum elemi, 4 ounces; best dragon's blood, 2 ounces; terra merita, 1½ ounces; oriental saffron, 4 grains; seed-lac, 2 ounces; pounded glass, 6 ounces; pure alcohol, forty ounces. The dragon's blood, gum elemi, seed-lac, and gamboge, are all pounded and mixed with the glass. Over them is poured the tincture obtained by infusing the saffron and terra merita in the alcohol for 24 hours. This tincture, before being poured over the dragon's blood, etc., should be strained through a piece of clean linen cloth, and strongly squeezed. If the dragon's blood gives too high a color, the quantity may be lessened according to circumstances. The same is the case with the other coloring matters. In choosing the terra merita, select that which is sound and compact. This lacquer has a very good effect when applied to many cast or moulded articles used in ornamenting furniture, the irregularity of surface of which would render it difficult, if not impossible, to polish in the ordinary manner.

3063. To Make Lacquer of Various Tints. Put 4 ounces best gum gamboge into 32 ounces spirits of turpentine; 4 ounces dragon's blood into the same quantity of spirits of turpentine as the gamboge, and 1 ounce annotto into 8 ounces of the same spirits. The 3 mixtures should be made in different vessels. They should then be kept for about two weeks in a warm place, and as much exposed to the sun as possible. At the end of that time they will be fit for use; and any desired tints may be obtained by making a composition from them, with such proportions of each liquor as the nature of the color desired will point out.

3064. Durable and Lustrous Black Coating for Metals. The bottom of a cylindrical iron pot, which should be about 18 inches in height, is covered half an inch with powdered bituminous coal; a grate is then put in and the pot filled with the articles to be varnished. Articles of cast iron, iron wire, brass, zinc, steel, tinned iron, &c., may be subjected to the same treatment. The cover is then put on and the pot heated over a coke fire under a well-drawing chimney. In the beginning the moisture only evaporates, but soon the coking commences, and deep brown vapors escape, which irritate the throat. When the bottom of the pot has been heated for 15 minutes to a dull red heat, the coal has been mostly converted into coke; the pot is then removed from the fire, and after standing 10 minutes opened for evaporation, all the articles will be found covered with the above described coating. This lacquer is not only a protection against oxidation of metals, but will stand also a considerable heat, only disappearing at beginning redness, and therefore its useful application for ovens and furnaces. The coating produced is thin, lustrous, and cannot easily be scratched. Fine iron ware articles, such as sieves, are in this manner coated with remarkable evenness, which cannot be accomplished in any other way. Articles made of tin, or soldered, cannot be subjected to this process, as they would fuse. Smaller articles, like hooks and eyes, receive this coating by heating them together with small pieces of bituminous coal in a cylindrical sheet iron drum like that used for roasting coffee, until they present the desired lustrous black appearance.

Method of Marbling Books.

This is performed by laying the color on the edges with a brush, or by means of a wooden trough and gum-water as follows:—Provide a wooden trough, 2 inches deep, 6 inches wide, and the length of a super-royal sheet; boil in a brass or copper pan any quantity of linseed and water until a thick mucilage is formed; strain it into the trough, and let it cool; then grind on a marble slab any of the following colors in small beer. For—

Blue, Prussian blue or indigo.

Red, rose-pink, vermilion, or drop lake.

Yellow, King's yellow, yellow ochre, &c.

White, flake white.

Black, ivory or burnt lampblack.

Brown, umber, burnt umber, vandyke brown, sienna, burnt sienna; black mixed with yellow and red, also makes brown.

Green, blue and yellow mixed.

Orange, red and yellow mixed.

Purple, red and blue mixed.

For each color you must have two cups, one for the color after grinding, the other to mix it with ox-gall, which must be used to thin the colors at discretion. If too much gall is used, the color will spread; when they keep their place on the surface of the trough, when moved with a quill, they are fit for use. All things being in readiness, the colors are successively sprinkled on the surface of the mucilage in the trough with a brush, and are waved or drawn about with a quill or stick, according to taste. When the design is thus formed, the book, tied tightly between cutting-boards of the same size, is lightly pressed with its edge on the surface of the liquid pattern, and then withdrawn and dried; the covers may be marbled in the same way, only letting the liquid colors run over them. The film of color in the trough may be as thin as possible, and if any remains after the marbling, it may be taken off by applying paper to it before you prepare for marbling again.

3103. Blue Sprinkle for Bookbinders. Strong sulphuric acid, 8 ounces; Spanish indigo, powdered, 2 ounces. Mix in a bottle that will hold a quart, and place it in a water-bath to promote solution. For use, dilute a little to the required color in a teacup.

3104. Blue Marble for Books, &c. Color the edges with King's yellow, and when dry tie the book between boards. Throw on blue spots in the gum trough, wave them with the iron pin, and apply the edges thereon.

3105. Brown Color for Marbling or Sprinkling Books. Logwood chips, 1 part; annotto, 1 part; boil in water, 6 parts. If too light, add a piece of copperas about the size of a pea. Or: Umber, any quantity. Grind it on a slab with ox-gall and a little lampblack. Dilute with ale.

3106. Gold Sprinkle for Books. Put into a marble mortar ½ ounce pure honey and 1 book of gold leaf; rub them well together until they are very fine, add ½ pint of clear water, and mix them well together. When the water clears, pour it off, and put in more, till the honey is all extracted, and nothing remains but the gold. Mix 1 grain corrosive sublimate in a tea-spoonful spirits of wine, and when dissolved, put the same, together with a little gum water, to the gold, and bottle it close for use. The edges of the book may be sprinkled or colored very dark, with green, blue, or purple, and lastly with the gold liquid, in small or large spots, very regular, shaking the bottle before using. Burnish the edges when dry, and cover them with paper to prevent the dust falling thereon. This sprinkle will have a most beautiful appearance on extra work; ladies may use it for ornamenting their fancy work, by putting it on with a pen or camel's hair brush, and when dry burnishing it with a dog's tooth.

3107. Marble for Leather Book-Covers. Wash the cover and glair it, take a sponge charged with water, having the book between wands, and drop the water from the sponge on the different parts of the cover; sprinkle very fine with vinegar black, then with brown, and lastly with vitriol water. Observe to sprinkle on the colors immediately after each other, and to wash the cover over with a clean sponge and water.

3108. Chinese Edge for Books. Color the edge with light liquid blue and dry; then take a sponge charged with vermilion, and dab on spots according to fancy; next throw on rice, and finish the edge with dark liquid blue. Color light blue on different parts of the edge with a sponge; do the same where there are vacancies with yellow and Brazil red; dry and dab on a little vermilion in spots; then throw on rice, and finish with a bold sprinkle of dark blue. Burnish.

3109. Wax Marble for Leather Book-Covers, &c. This marbling must be done on the fore edge, before the back of the book is rounded, or becomes round, when in boards, and finished on the head and foot. Take bees' wax and dissolve it over the fire in an earthen vessel; take quills stripped of their feathers, and tie them together; dip the quill-tops in the wax, and spot the edge, with large and small spots; take a sponge charged with blue, green, or red, and smear over the edge: when done, dash off the wax, and it will be marbled. This will be useful for stationery work, or for folios and quartos.

3110. Yellow Egyptian Marble for Leather Book-Covers. Boil quercitron bark with water and a little powdered alum, over a slow fire, until it is a good strong yellow. Pour the liquid into a broad vessel, sufficiently large to contain the cover when extended. Before the liquid is cool, take the dry cover, and lay the grain side flat on the color; press it lightly that the whole may receive the liquid; let it soak some time, and then take it from the vessel. The book must be covered in the usual manner, and permitted to dry from the fire. Glair the book; when dry, place it between the wands; take a sponge and water, and press large spots thereon; dip a quill-top into the vinegar black, with it touch the water on the cover in different parts, which will have a fine effect when managed with care. Let it stand a few minutes, then take off the water with a clean sponge.

3111. Green Egyptian Marble for Leather Book-Covers. Color the cover in a large vessel, as mentioned before, with Scott's liquid blue; when done, put it into a vessel of clear water for an hour. Take it out and press out the water, then cover the book. Glair the cover; when dry, place it between wands, and drop weak potash water from a sponge thereon; dip the quill-top into the strong black, and touch the water with it. This must be repeated till you have a good black. When dry, clear it with a sponge and water.

3112. Red Egyptian Marble for Leather Book-Covers. Boil Brazil dust in rain-water on a slow fire, with a little powdered alum and a few drops of solution of tin, till a good color is produced. Dip a piece of calf leather into the liquid, and you may ascertain the color wanted. If too light, let it boil till it is reduced to one half of the quantity; take it from the fire, add a few more drops of the solution of tin, and pour it into a large vessel. Put the dry cover on the liquid, and let it remain for a quarter of an hour, then press out the water. Color it over with a sponge and the quercitron bark water, and cover the book. Glair the cover, place it between wands, dash on water with a brush, also potash water; and, lastly, finish it with the strong vinegar black, with the quill-top. Observe that too much black is not put on; the intention of the marble is to show the red as transparently as possible.

3113. Green Marble for Leather Book-Covers. The edge must be marbled with a good bright green only. When the color is prepared with the ox-gall, and ready for use, a few drops of sweet oil must be mixed therein, the color thrown on with a brush, in large spots, till the gum is perfectly covered. The oil will make a light edge round each spot, and have a good effect. Blue, green, and brown may be also used separately in like manner. Sheets of paper may be done, having a trough large enough, and the sheets damped as for printing, before marbling. Spirits of turpentine may be sprinkled on the colors, which will make white spots.

3114. Binders' Thread Marble. Yellow the edge; when dry, cut pieces of thick thread over the edge, which will fall on different parts irregularly; give it a fine dark sprinkle, and shake off the thread. This produces a neat marbled appearance.

3115. Rice Marble, for Leather Book-Covers. Color the cover with spirits of wine and turmeric, then place on rice in a regular manner; throw on a very fine sprinkle of copperas water till the cover is nearly black, and let it remain till dry. The cover may be spotted with the red liquid or potash water, very freely, before the rice is thrown off the boards.

3116. Orange Color for Marbling or Sprinkling Books. Ground Brazil wood, 16 parts; annotto, 4 parts; alum, sugar, and gum-arabic, each 1 part; water, 70 parts. Boil, strain, and bottle.

3117. Tree Marble, for Leather Book-Covers. A marble in the form of trees may be done by bending the boards a little on the centre, using the same method as the common marble, having the cover previously prepared. The end of a candle may be rubbed on different parts of the boards, which will form knots.

3118. Vinegar Black for Bookbinders. Steep iron filings or rusty iron in good vinegar for two or three days, then strain off the liquor.

3119. To Sprinkle Books. Take a stiff brush made of hogs' bristles, perfectly clean, dip it in the color; squeeze out the superfluous liquid; then rub a folding-stick across the brush, and a fine sprinkle will fall on the edge of the book, which should be previously screwed tight in the cutting-press. Repeat the operation until the color is thrown equally on every part of the leaves. The brush should be held in the left hand, and the stick in the right.

3120. Chinese Marble for Leather Book-Covers. Color the cover of the book dark brown, and when dry put it into the cutting-press, with the boards perfectly flat; mix whiting and water of a thick consistence and throw it on, in spots or streaks, some large and some small, which must remain till dry. Spot or sprinkle the cover with liquid blue, and lastly throw on large spots of liquid red. The colors must be dry before washing off the whiting.

3121. Orange Sprinkle for Books. Color the edge with King's yellow, mixed in weak gum-water, then sprinkle with vermilion mixed in the same manner.

3122. Purple Sprinkle for Bookbinders. Logwood chips, 4 parts; powdered alum, 1 part; soft water, 24 parts. Boil until reduced to 16 parts, and bottle for use. Or: Brazil dust (fine), and mix it with potash water for use.

3123. Soap Marble for Books. This is applicable for marbling stationery, book edges, or sheets of paper for ladies' fancy work. Grind, on a marble slab, Prussian blue, with water, and a little brown soap, to a fine pliable consistence, that it may be thrown on with a small brush. Grind King's yellow in the same manner, with water and white soap. When green is intended for the ground color, grind it with brown soap, and King's yellow with white soap. Lake may be used for a ground color, and Prussian blue ground with white soap; brown umber for a ground color, and flake-white ground with white soap. Any color of a light substance may be ground for marbling.

3124. Spotted Marble for Books. After the fore-edge of the book is cut, let it remain in the press, and throw on linseeds in a regular manner; sprinkle the edge with any dark color, till the white paper is covered, then shake off the seeds. Various colors may be used. The edge may be colored with yellow or red before throwing on the seeds and sprinkling with blue. The seeds will make a fine fancy edge when placed very thick on different parts, with a few slightly thrown on the spaces between.

3125. Brown Sprinkle for Leather Book-Covers. Pearlash or potash, 1 part; soft water, 4 parts. Dissolve and strain.

3126. Red Sprinkle for Binders. Brazil wood (ground), 4 parts; alum, 1 part; vinegar, 4 parts; water, 4 parts. Boil until reduced to 7 parts, then add a small quantity of loaf-sugar and gum. Bottle for use.

3127. Black Sprinkle for Leather Book-Covers. Green copperas, 1 part; soft water, hot, 6 parts. Dissolve.

Photography.

Photography is based upon the law or principle that sunlight decomposes certain combinations of the salts of silver. For instance, if a piece of paper is first dipped into a solution of chloride of sodium (common table salt,) and then, when dried, floated on a solution of nitrate of silver, it will, upon being brought to the light, begin to darken, and finally assume an absolute black. It will be seen that if any opaque or semi-opaque body is interposed between the light and the paper, that portion which is so protected from the action of the light remains white, and thus impresses upon the paper, in a negative condition, the form or figure of the article so used.

The entire matter embraced in Nos. 3128 to 3154 is contributed by the eminent photographer, Mr. Geo. G. Rockwood, of New York.

3129. To Make a Photograph Without a Camera. The art of photography has many interesting and useful applications other than portraiture, one of the simplest and most beautiful of which we here present. It can be applied to the copying of laces, drawings, leaves, or anything of a transparent or translucent nature. It is proposed to first describe the manipulations, and then give the formulæ.

3130. Papier Saxe for Photography. The best is the papier saxe, an article made expressly for photography, and may be obtained from any dealer in photographic materials. It is sold in sheets about 18 by 22 inches. The smooth side can be easily selected, and upon that side the print should be made. Cut the paper into the sizes most convenient for the style of picture desired, and prepare the salting solution as follows:

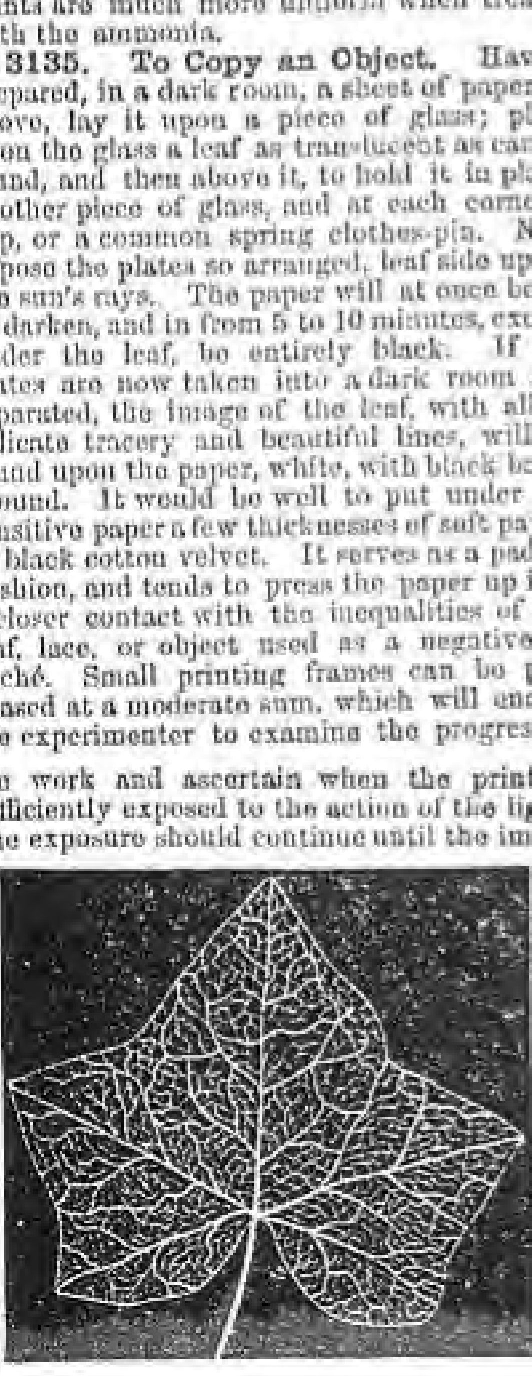
3131. Salting Solution for Photographic Paper. Mix together pure water, 16 ounces; chloride of ammonium or of sodium, 160 grains. Take enough of this to cover a shallow dish of porcelain to the depth of ½ inch or more, and then immerse the paper, one sheet at a time. When a half dozen are in, turn them all over, and take them out one by one, in the order in which they were immersed, and hang them up separately to dry.

3132. Albumenized Paper for Photography. Albumenized paper, such as is used for ordinary portraiture in the galleries, is always ready prepared for silvering. It is much the finest and sharpest in its results, and will usually be adopted; but the most artistic effects will be produced by the use of plain papier saxe. Paper, in either of these forms, prepared with chloride (salt) will keep indefinitely.

3133. Silver Solution to Sensatize Paper. The weather being propitious for printing (a clear, bright sunlight is preferable), the salted or albumenized paper is taken into a darkened room to be rendered sensitive by the silver solution. Make about the same quantity of this as of the salting solution, by using, in the following proportions: Pure water, 1 ounce; nitrate of silver (in crystals), 60 grains. When thoroughly dissolved, pour the solution into a flat porcelain dish, and carefully remove all bubbles, &c.

3134. To Make the Paper Sensitive. Having prepared the silver solution as above directed, take the paper by opposite corners, smooth side down if plain paper, glazed side if albumenized; lower one corner on to the solution, and steadily lower the rest to the surface of the solution, so that the air is completely driven out, and the entire surface exposed to the action of the silver. Be very careful that the solution does not get on the back of the paper. Plain paper (papier saxe) should float 2 minutes; albumenized, 3 minutes. Carefully raise the sheet from the solution, and hang up to dry in a perfectly dark room. It is best to proceed with the printing as soon as the paper is dry. Additional brilliancy and sensitiveness is imparted to the paper by exposing it, after it is thoroughly dry, to the fumes of ammonia. This may be done by hanging it up with a clip or pin in a close box, in which is a small dish containing aqua ammonia F.F.F. This fuming process may be dispensed with, yet the prints are much more uniform when treated with the ammonia.

3135. To Copy an Object. Having prepared, in a dark room, a sheet of paper as above, lay it upon a piece of glass; place upon the glass a leaf as translucent as can be found, and then above it, to hold it in place, another piece of glass, and at each corner a clip, or a common spring clothes-pin. Now expose the plates so arranged, leaf side up, to the sun's rays. The paper will at once begin to darken, and in from 5 to 10 minutes, except under the leaf, be entirely black. If the plates are now taken into a dark room and separated, the image of the leaf, with all its delicate tracery and beautiful lines, will be found upon the paper, white, with black background. It would be well to put under the sensitive paper a few thicknesses of soft paper, or black cotton velvet. It serves as a pad or cushion, and tends to press the paper up into a closer contact with the inequalities of the leaf, lace, or object used as a negative or cliché. Small printing frames can be purchased at a moderate sum, which will enable the experimenter to examine the progress of the work and ascertain when the print is sufficiently exposed to the action of the light. The exposure should continue until the image is much darker than intended when finished, as the after processes of toning and fixing reduce or bleach the pictures very considerably. As the prints are taken out of the frame, put them away in the dark again, until ready for the toning bath.



3136. To Prepare a Picture for Toning and Fixing. It will now be necessary to *tone* and *fix* the picture, in order that the image be rendered permanent. The first process is to soak the print in a dish of clear water for a few minutes, and thus wash off the free nitrate of silver remaining upon the surface of the paper. A half hour's soaking, with one or two changes of the water, will effect this so that it is ready for the toning bath.

3137. To Prepare a Toning Bath. Chloride of gold is sold in bottles containing 15 grains. Dissolve this in 30 drachms of water, add a drop of hydrochloric acid, and preserve it as a stock solution in a bottle; mark this *gold solution*. Make in another bottle a saturated solution of washing soda, also as a stock solution; mark it as such: *Soda solution*. When the prints have been washed as before directed, and are ready for toning, mix 1 drachm of the gold solution with 1 ounce of water, according to formula. Pour into a tray, and drop in a small piece of blue litmus paper; it will become red. Render the bath alkaline by adding from the soda solution, drop by drop, until the paper begins to change blue again. It is better to prepare the toning bath during the day, while the printing is being done, as the bath seems to work with more smoothness and uniformity. It may be used, however, so soon as mixed.

3138. To Tone a Picture. The print is now taken by two corners and immersed in the gold or toning bath. At first the print will begin to bleach, and turn a warm red color, which soon changes into a beautiful warm black. Put in the prints one by one, keeping them separated or constantly in gentle motion, when the changes already spoken of will occur. When a deep purple or warm black is obtained, remove them to a basin of clean water, and rinse them until all are toned, when they are ready for immersion in a fixing bath, to render them permanent.

3139. To Prepare a Fixing Bath. Take water, 6 ounces; hyposulphite of soda, 1 ounce. This solution dissolves from the paper all of the chloride of silver that has not been acted upon by the light, but does not injure the picture or image. The usual time for leaving the print in this bath is about 15 minutes. If the print is held up to transmitted light before it is placed in this solution, it will appear quite opaque and cloudy in what should be the clear parts of the picture. After the print has been in the bath the proper time this will disappear, and the print have a clear, translucent effect. The print should now be washed in 2 or 3 waters, and left to soak in a dish of water all night. In the morning it can be hung up to dry, and then mounted, as the taste of the experimenter may suggest. If the saving of time is an object, the print, after coming from the fixing bath, can be rinsed in water and passed through a common clothes-wringer a few times, each time being dipped in clean water, when the print will be found to be perfectly washed. When properly fixed, as already described, they are to be washed, and finally mounted on card or bristol board. The best paste for this purpose is common laundry starch.

3140. Precautions to be Observed in Making a Picture. When directions are given to prepare and keep the sensitive paper in a dark room, it should, of course, be understood that daylight only is to be excluded; gas or candle light will do no harm. A window closely covered with yellow paper completely filters the light of all actinic or chemical power, and consequently will do no harm. Be careful that not a drop of the fixing solution gets into the gold or toning bath. After the final process of fixing, take the greatest care that the prints do not again come into contact with the hyposulphite of soda. Soda is good—indispensable in its place, but exceedingly harmful out of its place. So keep all the dishes and fingers free from it. In all of the manipulations, observe the most perfect neatness. Handle the prints with the tips of your fingers, and always with deliberation and care. If the silver solution grows weak by use—a mealy look to the prints indicates it—add a few grains of nitrate of silver. If by use it turns a dark wine color, and the paper is not white when dry, set the solution in clear sunlight for a day or two and it will clear. Filter before using again. The soda (fixing) bath should not be used more than 2 or 3 times. Where prints are only occasionally made, a fresh bath should be made each time of printing. The gold (toning) bath works quicker when warmed to about blood heat. Prints will then tone in from 2 to 6 minutes. Prints on plain paper will tone quicker than on albumenized. If prints are undertoned they will present a warm brown appearance; if toned too much, a cold steel color. A little experience will soon indicate the precise amount of toning required.

3141. To Remove Nitrate of Silver Stains. An inevitable consequence of practicing this process will be stains on the hands and clothing from the nitrate of silver. Moisten the spots with tincture of iodine, and then with a saturated solution of hyposulphite of soda. Cyanide of potassium acts more energetically, but is a very dangerous poison, and is not recommended.

3142. The Photographic Negative or Cliché. In number 3128 we have stated the general principles of the photographic art; that it was based upon the fact that solar light decomposes certain combinations of the salts of silver; that in proportion or to the extent that such sensitive surface is exposed to the action of light, so is the depth of the stain or intensity of the image upon the prepared paper. Now if we should cut from an opaque or black piece of paper, any form or figure—an old fashioned *silhouette* would be a familiar illustration—and place it upon the silvered paper, the precise image or form cut in the paper would, upon removal, be found upon the paper; the paper remaining white under the figure leaf or "*theorem*," while the parts exposed to the light have turned black. In place of this figure, science has given us *the Photographic Negative or Cliché*. A negative is an image produced upon glass by a camera (an improved form of the old camera obscura) and derives its name from the fact that the image is *reversed* or *negative* by transmitted light (looking *through* it), the lights appearing dark, and the dark parts light. The chemicals used to produce it are also combinations of the salts of silver, but are so sensitive to the action of light, that they are decomposed *instantaneously* by exposure. The formulæ will follow a description of the process.

3143. To Make a Photographic Negative. In a room illuminated only by a feeble gas or candle light, or by such daylight as is filtered of its chemical power through a sheet of yellow glass, a glass plate is carefully flowed with collodion. (*See No.* 3149.) When the plate has been evenly covered, the excess is quickly but *deliberately* returned to the bottle, and the plate gently and slowly swayed from side to side until the collodion is set, or when the surface is tacky to the touch. It is then placed on a dipper, and, with a steady, continuous motion, immersed, collodion side upwards, in the silver bath. (*See No.* 3150.) If the plate is stopped in its descent into the bath, a *check* or line will show across its face. In 3 to 5 minutes, depending upon temperature, etc., the plate is *coated*, or, in other words, the chemicals in the collodion have united with the nitrate of silver, forming the sensitive surface or coating. If not coated sufficiently the surface will appear *greasy;* in this case the plate must be returned to the bath until the film appears perfectly smooth. While this is being done it is supposed that the operator has adjusted the camera upon the object to be photographed by focussing his lens. This is done by turning the lens in and out, or from and towards the ground glass of the camera, until the point is ascertained which gives the sharpest image upon the ground glass. All being ready, the operator returns to the dark room for his sensitive plate. This is placed in a "holder," and the ground glass being removed, the holder is substituted in its place. The slide or cover to the holder is now withdrawn and the sensitive plate exposed to the action of the image of light thrown upon it by the lens. After an exposure of 15 to 60 seconds, depending so much upon the intensity of the light that it can only be ascertained by experience, the slide is replaced in the holder and the plate taken to the dark room for development.

3144. To Develop a Negative. This is done by removing the plate from the holder, and, holding the plate in a horizontal position, flowing it with the developing solution. (*See No.* 3151.) If properly timed or exposed, the image begins to appear. When the details of the drapery, if a portrait, appear and the solution seems to have lost its power, the plate is thoroughly washed under a stream of clean water. If the image is sufficiently strong and vigorous, it is "cleared" by placing the plate in the fixing bath, and that portion of the film *not* acted upon by the light is dissolved away, leaving the image upon the glass. After a thorough washing in water, the plate is put in a rack to dry, after which it is slightly warmed and varnished.

3145. To Varnish a Negative. The varnish (*see No.* 3153) is flowed on and off precisely as with the collodion. (*See No.* 3143.) It should be again slightly warmed to prevent the varnish from chilling or *blooming*. When dry, which will be in 5 to 10 minutes, the negative is ready for use as described in *Nos.* 3135, &c., using the negative instead of the leaf. Should the image have evidence of full exposure by the existence of all the proper detail, and yet want vigor or intensity, this may be imparted, *before* varnishing, by *re-development*.

3146. To Re-develop a Negative. This is done by pouring upon the plate about 1 ounce of the pyrogallic acid solution to which has been added 5 or 6 drops of the silver solution designated for that purpose. (*See No.* 3152.)

3147. Glass for Photography. For portraiture and ordinary landscape photography, the best qualities of picture or window glass will suffice. There is an article sold by dealers in photographic materials, known as photographic or negative glass, which is selected for the purpose and cut into the regular sizes used in the art, viz., stereoscopic, "quarter" size, "half" size, "four-four" &c., the latter being 6½×8½ inches and the other sizes fractional parts, as their names suggest. For microscopic and scientific experiments, plate glass would be preferable. A quality known as "three quarter white" plate, and only of the thickness of ordinary single thick window glass, has all the requisites for *exact* photography. When it is proposed to print photographs upon glass, for magic lanterns or transparencies, plate glass is absolutely essential.

3148. To Prepare Glass for Photography. All new glass should be placed for a few minutes in a strong solution of commercial nitric acid (say 1 ounce nitric acid to 3 ounces water), and then thoroughly washed in clean water. While wet, pour upon the glass a solution consisting of white of egg, 1 ounce; water, 20 ounces; drain off into a separate bottle, or clean, filter, and set up in a rack to dry. The albumen and water solution, before using, should be very thoroughly beaten together. After the froth has subsided, filter the solution through a clean sponge, two or three thicknesses of linen, or, still better, filtering paper. The solution above named will coat more plates than an amateur would be likely to use. *Use fresh eggs and a newly made solution whenever coating plates.* The plates so prepared will keep indefinitely.

3149. Collodion for Photography. Collodion is the vehicle by which the photographic chemicals are united upon the surface of the glass and the sensitive coating produced. It is made by dissolving in equal or nearly equal proportions of sulphuric ether and alcohol, gun cotton or pyroxyline together with certain salts of potassium, cadmium, ammonium, &c., in proportions named in the formulæ. Many formulæ are published for this article to which great value is attached, some supposing that to its peculiar composition belong the principal causes of failure or success. This is only in a degree true. Inferior or carelessly prepared chemicals used in any stage of the process impair results. The writer has fixed as a general principle in the preparation of collodion the proportion of 1 grain of the exciting salts (in each ounce of collodion), to every 10 grains of silver in the bath. To illustrate: If the silver bath solution is at 50°, or, more definitely, 50 grains of silver to each ounce of water, we would make the collodion so as to contain in each ounce of collodion 5 grains of the various salts of cadmium, ammonium, &c.; or another way of putting it, the bath should be ten times as strong as the collodion. The sensitizing salts should be selected with a special reference to the peculiarities of the light or subjects. It can be made under one formula to cover almost all emergencies; yet special kinds of work for extremes of light or shadow can be improved by varying the combinations of the exciting or sensitizing salts. For portraiture in a room of evenly diffused light the iodide of cadmium as the principal excitant gives softness and delicacy to the image. Thus:

I. Take of sulphuric ether, 1 ounce; 95 per cent. alcohol, 1 ounce; gun cotton, 6 grains; iodide of cadmium, 4 grains; bromide of cadmium, 2 grains.

II. Sulphuric ether, 1 ounce; alcohol, 1 ounce; gun cotton, 6 grains; iodide of cadmium, 3½ grains; bromide of potassium, 2½ grains.

These two formulæ give the utmost delicacy and transparency to the shadows, and work with rapidity, when preserving their proper relations to the silver bath solution, of which we speak in the proper place. If more brightness is desired to the image, instead of the iodide of cadmium put the same quantity of iodide of ammonium. If still greater contrasts are required, use iodide of potassium in place of either the cadmium or potassium. The latter is favorable for copying engravings, maps, plans, &c., in which strong contrasts of white and black are desirable. It is well to prepare from all these formulæ and then modify results by mixing them together as the subjects or light may demand. Further combinations may be suggested; under a feeble light, or where there are large masses of shadow, *reduce* the amount of the iodide salt one grain and *increase* the bromide one grain.

IN COMBINING THE INGREDIENTS, measure out the required quantity of alcohol, and *to it* add the gun cotton and such of the exciting salts as dissolve in alcohol, and lastly the ether. Shake until all are thoroughly dissolved, and put aside over night to settle. When clear, decant into the flowing or coating bottle for use. Such of the excitants as do not dissolve in alcohol should be dissolved in as small a quantity of water as is possible and added to the alcohol, &c., *a little at a time*, and quickly shaken.

3150. Silver Bath. Make a solution in the proportion of 60 grains nitrate of silver to 1 ounce water. Test the solution with litmus paper, and if slightly alkaline, or neutral, add nitric acid to produce a *faint* red reaction to the paper. The best method is to add a few drops of chemically pure nitric acid to an ounce of water, and add this solution to the silver bath a *very few* drops at a time. Then coat a plate with collodion and let it remain in the bath all night. The freshly made collodion can be used for this purpose, and thus both collodion and silver solution or bath be made ready for work at the same time.

3151. Developing Solution. This may be made in stock solution of the simple sulphate of iron and water, and then reduced in strength and made ready for use each day. For the stock solution take water, 16 ounces; sulphate of iron, 4 ounces. Dissolve and filter. When wanted for use, take stock solution, 1 ounce; water, 4 ounces; acetic acid (*No.* 8), ½ ounce. The addition of about ½ ounce alcohol to the above formula often facilitates the smooth flowing of the solution on the plate. It is particularly essential when the bath has been in long use and is "saturated" with ether and alcohol from the plates.

3152. Re-developing Solution, for adding vigor and intensity to the negative, is made of water, 1 ounce; pyrogallic acid, 1 grain; citric acid, 1 grain. Pour into a small beaker or cupping glass about 1 ounce of this solution, and add, by means of a pipette, 5 or 6 drops of a solution of 20 grains nitrate of silver dissolved in 1 ounce water. Immediately flow this solution over the plate, occasionally returning the solution to the little beaker glass. As soon as the solution begins to assume a wine color, it is acting with vigor on the negative and should be closely watched, that the negative does not become too intense. When sufficiently dense, throw away the solution and thoroughly wash both the negative and the glass. The latter should always be kept perfectly clean and free from any deposit from the re-developing solutions.

3153. Negative Varnish of excellent quality can always be secured at the dealers in photographic materials. In an emergency common shellac varnish, somewhat thinned down with alcohol, and filtered through cotton, will answer the purpose. (*See No.* 2935.)

3154. The Causes of Failure would almost require a chapter by themselves; a long experience convinces us that nine out of every ten failures occur from a want of care, the presence of dirt, negligence. One cannot be over-nice, careful or cleanly—the best results always rewarding the most painstaking.

3155. To Enamel Cameo Pictures. Ordinary well polished glass plates are coated with normal collodion of the usual description, and when the film has set perfectly, but has not become completely dry, the pictures, which have previously been trimmed and finished, are dipped rapidly into alcohol, and applied without delay to the plates. The prints are pressed and rubbed down with smooth writing paper, and the operation of mounting is proceeded with as soon as the backs of the pictures have become white; or, in other words, as soon as the alcohol has again evaporated. The cardboard should be allowed to remain in water for at least half an hour previously to its being employed for mounting. The more rapidly the pictures are applied and pressed upon the collodion surface, the more beautiful will be the finished result.

3156. Photographic Impressions With Fuchsine. A piece of linen goods colored with fuchsine, and dried, was exposed to the light under a photographic negative, when the image of the plate became visible on the goods, the picture looking greyish and faded where the lights were strongest. Still the picture was rather weak, and the goods were soaked for 2 days in a bath of sulphate of copper, when the picture was found to be more developed. After several rinsings in water, and two days' exposure on the grass, the rest of the goods were bleached white, leaving the picture of a pure violet tint on a white background.

3157. Tapioca Paper. To prepare tapioca paper, which is very useful for copying photographs by artificial light, 200 grammes (6½ Troy ounces) of tapioca are soaked for 2 days in an equal weight of water; 10 litres (about 21 pints) of water are added, and afterwards, for every litre (quart) of liquid, 10 grammes (154 grains) iodide of potassium, 30 grammes (463 grains) chloride of potassium, 1 gramme (15½ grains) bromide of potassium, are dissolved, and the whole boiled for 10 minutes, allowed to stand for a day, and decanted and filtered through fine linen. The paper is immersed, 12 or 20 sheets at a time—or can be floated upon it—for 15 to 20 minutes; it is then hung up to dry in a dark room. If it has assumed a dark color, that is of no consequence, as it disappears in the silver bath. This is to be prepared in the proportion of 1 ounce nitrate of silver, 50 to 60 grains of citric acid in 30 ounces of water. The time of exposure varies from 10 seconds to 25 minutes, according to the picture to be copied and the actinic force of the light.

3158. To Recover Gold and Silver from Photographic Solutions. The silver and gold waste that result from photographic operations are best collected in a large bottle or jar, together with anything else that might contain either of the two metals. When the bottle is nearly full, pour a little hydrochloric acid and a solution of green sulphate of iron (copperas) into it, and let it stand on a warm place until the supernatant liquid appears perfectly clear. Add then a few drops more of the hydrochloric acid and iron solution, and observe whether a fresh precipitate forms or not. In the latter case, draw the clear liquid off by means of a syphon, and reserve the residue. If the bottle has become partially filled in course of time with insoluble chloride of silver and metallic gold, place the residue on a filter, wash it with very dilute acid, and, lastly, with water. After drying, it is to be mixed with several times its weight of dry carbonate of soda, the whole conveyed to a crucible, and the latter heated to a bright red heat, and kept there for about 10 minutes. After taking the crucible out of the fire, and allowing it to grow cold, it is broken, the button of the alloy of gold and silver cleaned, and heated in a suitable vessel with dilute nitric acid, which will dissolve all the silver, as nitrate of silver, and leave the gold in a finely divided state. This is dissolved by nitro-hydrochloric acid (aqua regia). It is hardly necessary to say that, for photographic purposes, both solutions must be evaporated in a water-bath until the excess of acid has been volatilized, when they may be diluted with a sufficient amount of water, and used. (*See No.* 3166.)

3159. Simple Method of Copying Drawings, Etc. Silvered albumen paper, after being washed, may be conveniently used for copying negatives as well as positives. It keeps for weeks, and becomes sensitive to light only after exposure to the vapors of aqua ammonia, technically termed smoking with ammonia. Dr. H. Vogel has greatly simplified the latter process by substituting for the liquid ammonia the powder of carbonate of ammonia. He thoroughly impregnates a piece of felt or cloth with this powder, and lays it under the silvered sheet, separated from it by a piece of blotting-paper. He places the silvered paper, with the substratum of carbonate of ammonia and the drawing on top, between two plates of glass, and, exposing it to the light of the window, obtains a copy quite distinct in all its details. The copy obtained is, of course, in white lines upon black ground. Such photographs require to be treated with soda when intended for long preservation.

3160. Lea's Solution for Cleaning Photographic Glasses. Water, 1 pint; sulphuric acid, ½ ounce; bichromate potash, ½ ounce. The glass plates, varnished or otherwise, are left, say 10 or 12 hours, or as much longer as desired, in this solution, and then rinsed in clean water, and wiped or rubbed dry with soft white paper. This preparation is by Mr. Carey Lea, of Philadelphia, and is said to be the best in use. It quickly removes silver stains from the skin without any of the attendant dangers of the cyanide of potassium.

3161. Wenderoth's Photographic Varnish. Nearly all photographic varnishes reduce the intensity of the negative. Mr. F. A. Wenderoth, of Philadelphia, states that if a thin solution of gum-arabic is applied to the negative after fixing and before drying, the varnish will not affect the intensity. This is a very simple and useful remedy. Mr. Wenderoth also states that he has long practiced the covering of photographic paper prints upon both sides with collodion varnish, and finds it a complete preservative of the picture. Nearly all photographs will fade away in a few years unless thus protected.

3162. Collodion Varnish for Photographic Prints. A very effective and agreeable polish is communicated to card or cabinet prints, etc., simply by coating them with a glutinous plain collodion, made as follows: Alcohol, 3 ounces; ether, 4 ounces; pyroxyline, 42 grains. Dissolve and filter in the usual manner. The prints are first cut to the proper size and floated on the reverse side upon clean water until they lie perfectly flat; then take one print at a time and place it on a piece of glass of the same size as itself, moist side downwards; it easily adheres to the glass. Let the excess of water drain off, and remove all moisture from the picture surface; now coat it with the collodion and let it drain in the usual way, then dry it before the fire or in any manner which is most convenient. This polish is not so flagrant on the one hand as the so-called enamel surface, nor so dead as an ordinary albumen print that has undergone all the operations up to the mounting.

3163. Preservation of Photographs. H. Cooper, Jr., of England, gives the following formula for a preservative varnish which is stated to be an entire protection against fading: 1 drachm gum damar dissolved in 1 ounce benzole. 1 drachm paraffine, dissolved in 1 ounce benzole. Mix 4 parts of the paraffine solution with 1 part of the damar solution. Photographic prints covered with this varnish are impermeable to water. A solution of the paraffine only will do; but it is better with the gum damar.

3164. Everlasting Photographs on Enamel. First-class photographs, either negatives or positives, may be taken on Duchemin's enamel (*see No.* 2402) without collodion, by using bitumen, or citrate of iron, or perchloride of iron and tartaric acid, or bichromate, or any other salt. A good solution for this purpose is, water, 100 parts by weight; gum, 4 parts; honey, 1 part; pulverized bichromate of potash, 3 parts. Filter the liquid, spread it over the enamel, and let it rest, after which, expose it to the camera. Develop the image by brushing over it the following powder: Oxide of cobalt, 180 parts by weight; black oxide of iron, 90 parts; red lead, 100 parts; sand, 30 parts. Decompose the bichromate by immersion in a bath formed of water, 100 parts by weight; hydrochloric acid, 5 parts. Wash it in clean water and dry it; and lastly, vitrefy the proof on a clean piece of cast iron, the surface of which has been previously chalked. One minute will suffice for indelibly fixing and glazing the photograph, which must be carefully and slowly allowed to cool. Photographs on enamel of any size, taken in this manner, are perfectly unalterable under all atmospheric conditions, and may consequently and aptly be called everlasting photographs.

3165. Searing's Process for Photographing on Wood for Engraving. The block on which the picture is to be made is first dampened with water, then whitened with enamel rubbed from the surface of good enameled visiting cards. Rub gently, removing only the enamel, after which it is brushed smooth with a moderately stiff brush, from right to left and up and down, making a smooth, even, and very thin surface. Allow this to dry, after which it is flowed with a solution of albumen, made with the white of 1 egg and 16 ounces of water, dried by heat or allowed to dry spontaneously. Now coat it with another albumen solution made as follows: White of 1 egg; water, 4 ounces; chloride of ammonia, 40 grains. Beat the whole to a thick froth. Allow to subside, then decant or filter through a fine sponge placed in a glass funnel. Pour a sufficient quantity on one corner of the block to cover it, when spread around with the aid of a ¼ or ⅛ glass (using the edge). Allow the surplus solution to drain back into the bottle. Dry this by a gentle heat. Next flow on, in the dark room, solution No. 3, prepared as follows: Ether, 1 ounce; alcohol, 1 ounce; gun-cotton, 8 grains; nitrate of silver, 30 grains; dissolve in as small a quantity of water as possible, and allow to settle for a few days, protected from the light. Again dry the block by gentle heat. It is now ready for exposure under the negative. A porcelain printing-frame, or any other suitable method, may be used to print it. After printing, solution *No.* 3 is removed from the surface of the block by dissolving in ether and alcohol, assisted by rubbing gently with a soft sponge. The picture can now be toned and fixed in the ordinary way, or fixed and toned at one operation, by the hypo and gold bath. After being allowed to dry, it is ready for the engraver.

3166. To Recover Silver from Photographic Waste. To obtain the silver from a photographic bath, or from the rejected photographs and clippings, is a most important measure of economy in the art. The bath should be filtered, and a solution of common salt added; this precipitates chloride of silver, which is to be collected on a filter, dried, and washed; then the metallic silver may be obtained from it by the action of metallic zinc, a strip of which being placed in the pulpy mass, will combine with the chloride, and leave the silver in a spongy mass of a gray color; after washing, this may be dissolved in nitric acid and crystallized. Another process is to mix the chloride with nitrate of potassa and fuse in a crucible—the silver is thus obtained in a button. The papers must be incinerated, the ashes collected and treated with nitric acid and heat; diluted with water, and filtered; it is now an impure solution of silver, to be treated in the same way as the bath. (*See No.* 3158.)

3167. To Clean off Collodion Pictures. A tuft of cotton dipped in methylic alcohol, and rubbed over the surface of the picture, will remove it entirely, whether varnished or not.

3168. Paper for Photography. The paper used for photography may be the finest satin post paper, of uniform texture, free from the maker's mark, specks, and all imperfections. The papers must be prepared by candle-light, and kept in the dark till used.

3169. Simple Nitrated Paper. This is merely paper brushed over with a strong solution of nitrate of silver. In brushing over the paper it must not be crossed. Its sensitiveness is increased by using spirits of wine instead of water. This paper only requires washing in water to fix the drawing.

3170. Muriated Paper. The paper is first soaked in solution of common salt, pressed with a linen cloth or blotting-paper, and dried. It is then brushed over on one side (which should be marked near the edge) with the solution of nitrate of silver, and dried at the fire. The stronger the solution, the more sensitive the paper. If the barytic solution (*see No.* 3181) be used instead of common salt, richer shades of color are obtained. A solution of 10 grains sal ammoniac in 1 ounce water gives a very sensitive paper. A due proportion must be observed in the silver and salt solutions, as follows:

Sensitive paper for the camera, use 50 grains common salt to 1 ounce water; and 120 grains nitrate of silver to 1 ounce water. Or: 60 grains of the nitrate with 40 grains muriate of ammonia, and 4 ounces water. Or: 100 grains nitrate with the barytic solution. (*See No.* 3181.)

Less sensitive, for copying engravings, botanical and entomological specimens, &c. The salt solution to contain 25 grains salt to 1 ounce water. The silver solution 90 grains in 1 ounce water.

For copying lace-work, feathers, patterns, &c. The salt solution, 20 grains; the silver solution, 40 grains to 1 ounce. To fix the drawing on these papers, they must be first washed in lukewarm water, then dipped twice in solution of hyposulphite of soda (1 ounce to 1 pint), then in pure water, and dried.

3171. Iodized Paper. Brush over the paper on one side (which should be marked) with strong solution of nitrate of silver (100 grains to 1 ounce); then dip it in solution of iodide of potassium (25 grains to 1 ounce); wash it in distilled water, drain, and dry it.

3172. Bromide Paper. Soak the paper in solution of bromide of potassium (40 grains to 1 ounce); then brush it over with strong solution of nitrate of silver, and dry in the dark.

3173. Chromatype Paper. Simple chromatype paper is prepared as follows: Soak the paper in the *simple* solution (*see No.* 3182), and dry it at a brisk fire. To fix the drawing, careful immersion in warm water is all that is required. It is not sufficiently sensitive for the camera.

For Compound Chromatype Paper. Wash the paper with the *compound* solution (*see No.* 3182), and dry it. After the paper has been exposed to the sun with the article to be copied superposed upon it, it is washed over in the dark with a solution of nitrate of silver of moderate strength. A vivid picture makes its appearance, which is sufficiently fixed by washing in pure water. For copying engravings, &c. Another method is to brush writing paper over with a solution of 1 drachm of sulphate of copper in 1 ounce of water; and when dry, with a strong but not saturated solution of bichromate of potash.

3174. Cyanotype Paper. Brush the paper over with a solution of ammonio-citrate of iron. Expose the paper in the usual way, then wash it over with a solution of ferrocyanide of potassium.

3175. Crysotype Paper. Wash the paper with solution of ammonio-citrate of iron, dry it, and afterwards brush it over with a solution of ferrocyanide of potassium. Dry it in a dark room. The image is brought out by brushing it over with a neutral solution of gold or of silver.

3176. Calotype Paper. The paper is saturated in 1 ounce water, containing 20 grains iodide of potassium, and dried. Then made sensitive by soaking in 1 ounce distilled water containing 20 grains nitrate of silver and ½ drachm glacial acetic acid, and dried in a dark room.

3177. Instantaneous Positive Paper. Mix 6 drachms of a saturated solution of bichloride of mercury with 1 pint distilled water. Float the paper on this solution in a flat dish. Dry it; take into a dark place lit by a candle with a yellow glass, and render it sensitive by a solution of 38 grains nitrate of silver to 1 ounce water. To print, expose to a perpendicular light from 2 to 10 seconds in summer, about 1 minute in winter; then immediately cover with a black cloth. The image, at first very feeble, is developed by this solution; sulphate of iron, 15 grains; glacial acetic acid, 25 grains; distilled water, 1 ounce. The deepening of tint must be watched, and arrested at the proper moment. Then wash, and fix with hyposulphite.

3178. Albumenized Paper for Positive Printing. White of egg, and water, equal parts; iodide of potassium or chloride of sodium, 5 grains to 1 ounce water (or bromide of potassium, 20 grains). Coat the paper with this solution. Dry. Immerse in the dark in bath of 120 grains nitrate of silver to 1 ounce water. Dry again. This is exposed with the negative over it, for 10 to 15 minutes.

3179. Prepared Wax Paper. Make a strong size by digesting 25 parts gelatine, 50 of linseed, and 150 of rice flour, in 2000 to 3000 parts hot water. Filter through a cloth. Take of this size, when cold, 1000 parts by weight, and dissolve in it sugar of milk, 50 parts; iodide of potassium, 35; bromide of potassium, 5 parts.

3180. Artificial Ivory for Photographers. Sheets or tablets of gelatine or glue are immersed in a solution of alumina. When entirely penetrated by the alumina, the slabs are to be removed, dried, and polished like ivory. (*Mayall.*)

3181. Barytic Photographic Solution. Dissolve 35 grains chloride of barium in 2 ounces distilled water.

3182. Chromate Photographic Solutions. *Simple chromate solution* is a saturated solution of bichromate of potash; a little sulphate of indigo being sometimes added to vary the color.

The *compound chromate solution* consists of 10 grains bichromate of potash, and 20 grains sulphate of copper, dissolved in 1 ounce distilled water.

3183. Hydriodate of Iron and Barytes Photographic Solution. Hydriodate of barytes, 40 grains; water, 1 ounce; pure sulphate of iron, 5 grains; mix, filter, add a drop or two diluted sulphuric acid, and when settled decant the clear liquor for use.

3184. Hardwich's Gold Toning Bath for Positive Printing. Pure chloride of gold, 1 grain; hyposulphite of soda, 1 to 3 grains; hydrochloric acid, 4 minims; water, 4 ounces.

3185. Mayall's Method of Cleaning Photographic Glasses. Shake up together 30 parts alcohol, 10 parts strong liquid ammonia, 40 parts water, and 30 parts fine Tripoli. The plates are to be rubbed hard and evenly with balls of cotton-wool dipped in the mixture. When dry, rub again with a clean ball of cotton, and dust off the back and edges with a clean hog's-hair brush.

Metals.

Metals are elementary or undecompounded bodies, which are distinguished by their weight, lustre, fusibility, power of conducting heat, electricity, &c. (*see Nos.* 3349 *to* 3357 *inclusive*), and the numerous compounds which they furnish by combination with one another, and with other bodies. When their solutions are decomposed by a galvanic current, the metals always appear at the electro-negative surface, and are hence termed *electro-positive* bodies.

3187. Assaying. The method of determining the quantity of pure gold and silver in the alloys of these metals. This art requires great skill and experience in its performance; and, from the costliness of the precious metals, is of the utmost importance. A downward draught furnace of any shape and size may be employed, provided it will afford a sufficient heat, and allow the introduction of the muffle. The muffle is a pot made of clay, and furnished with an opening at its end, to admit the introduction of the cupels, and to allow of inspection of the process. It is placed on the muffle-plate, by which it is introduced into the furnace. The cupel is a sort of shallow crucible, made of bone ashes or burnt bones. At the British mint the cupels are made of the calcined cores of ox-horns. The powder is slightly moistened with water, and a circular steel mould is filled therewith, and after being pressed down tight, is finished off with a rammer, having a convex face of polished steel, which is struck forcibly with a mallet, until the mass becomes sufficiently hard and adherent. The cupel is then carefully removed, and exposed in the air to dry, which usually takes from 14 to 21 days. The muffle, with the cupels properly arranged, being placed in the furnace, the latter is filled up with charcoal, and lighted at the top by placing a few pieces, heated to whiteness, on last. When the cupels have been exposed for half an hour, and have become white by heat, the lead is put into them by means of a pair of tongs, and as soon as this becomes thoroughly red and circulating, as it is called, the metal to be assayed, wrapped in a small piece of paper, is added, and the fire kept up strongly until the metal enters the lead, and circulates well, when the heat may be slightly diminished, and so regulated that the assay shall appear convex and ardent, while the cupel is less red—that the undulations shall circulate in all directions, and that the middle of the metal shall appear smooth, surrounded with a small circle of litharge, which is being continually absorbed by the cupel. This treatment must be continued until the metal becomes bright and shining, or is said to "lighten;" after which certain prismatic colors, or rainbow hues, suddenly flash across the globules, and undulate and cross each other, and the latter metal soon after appears very brilliant and clear, and at length becomes fixed and solid. This is called the "brightening," and shows that the separation is ended. In conducting this process, all the materials used must be accurately weighed, especially the weight of the alloy before cupellation, and the resulting button of pure metal. The difference gives the quantity of alloy. The preceding general description of the process of cupellation will render the following articles intelligible, without again entering into the minutiæ of the operation. An assay is thought to be good when the bead is of a round form, with its upper surface brilliant, its lower one granular and dead-white, and when it separates readily from the cupel. When the surface of the bead is dull and flat, it shows that too much heat has been employed; and if the metal be silver, some may have been lost in the process, by fuming or absorption. When the bead is spongy, and of various colors, and scales of litharge still remain on the cupel, and the metal adheres strongly to the latter, too little heat has been used, and the button still retains some lead. To remedy this, the heat should be raised, and a little powdered charcoal, or a few small pieces of paper, thrown into the cupel, until the metal again begins to circulate freely. It is necessary that the lead employed in the process of cupellation should be perfectly pure. It ought, therefore, to be procured by reducing refined litharge. (*Cooley.*)

3188. Puscher's Solution for Coloring Metals. This is a new method of giving metals a durable colored coating, and can be executed quickly and cheaply. To prepare the solution dissolve 1½ ounces hyposulphite of soda in 1 pound water, and add 1½ ounces acetate of lead dissolved in ½ pound of water. When this clear solution is heated to 190° to 210° Fahr., it decomposes slowly, and precipitates sulphide of lead in brown flocks. If metal is now immersed in it a part of the sulphide of lead is deposited thereon, and according to the length of time and consequent thickness of the deposited sulphide of lead, the various and beautiful lustre colors are produced. In 5 minutes there may be imparted to *brass* articles a color varying from a beautiful gold to a copper red; then carmine red, then dark, then light aniline blue, to a blue white, like sulphide of lead; and at last a reddish white, according to the length of time they remain in the solution used. The colors possess the most beautiful lustre, and if the articles to be colored have been previously thoroughly cleaned by means of acids and alkalies, they adhere so firmly that they may be operated upon by the polishing steel. To produce an even coloring, the articles to be colored must be evenly heated.

Iron treated with this solution takes a steel blue color; *zinc*, a brown color; in the case of *copper* objects the first gold color does not appear; lead and zinc are entirely indifferent.

If, instead of the acetate of lead, an equal weight of sulphuric acid be added to the hyposulphite of soda, and the process carried on as before, the *brass* is covered with a very beautiful red, which is followed by a green, and changes finally to a splendid brown with green and red iris-glitter; this last is a very durable coating, and may find special attention in manufactures. (*See No.* 3313.)

Very beautiful marbleized designs can be produced by using a lead solution thickened with gum tragacanth on brass which has been heated to 210° Fahr., and afterwards treated by the usual solution of sulphide of lead. The solution may be used several times, and is not liable to spontaneous change.

Gold.

The most marked properties of metallic gold are its ductility, malleability, and insolubility in all menstrua, except aqua regia and aqueous chlorine, and its slight affinity for oxygen. Native gold has a specific gravity of 13.3 to 17.7; pure gold, about 19.3; its greatest density is 19.5. Its fusing point is 2016° Fahr. It is characterized by its yellow color, its insolubility in nitric acid, and ready solution in nitromuriatic acid (aqua regia), forming a yellow liquid that stains the skin purple.

3190. Assay of Gold by the Use of Touch-Stones. When it is desired to ascertain the fineness of small quantities of gold, as in jewelry, &c., touch-needles and stones are employed. The former are made in sets, containing gold of different fineness and differently alloyed with copper and silver. Pieces of black pottery form excellent touch-stones. The mode of using them is to mark the stone with the sample under examination, and to compare its appearance, hardness, &c., with that produced by one or more of the needles. When the two are similar, the quality is considered to be the same. They are then further examined by moistening the stroke with aquafortis when red hot, when the appearances resulting from oxidation, etc., differ according to the nature and quantity of the alloy.

3191. Assay of Gold by Cupellation. This process is divided into five operations.

Cupellation. Either 6 or 12 grains of the alloy is the weight usually taken for the assay, to which is added 16 parts of lead for every 1 part of copper that it is presumed to contain, though considerably more lead may be used when the sample does not contain any silver; but if the reverse be the case, an excess of lead would tend to the loss of the latter metal, which ought not to be separated until the operation of parting. When silver is present an additional allowance of lead, equal to $\frac{1}{10}$ of its weight, is made on that account. When, however, the quantity of silver is small, or is not required to be estimated, it becomes of little consequence what weight of lead is employed, so long as enough be used to carry off the base metals, at the same time that the quantity is not too large for the cupel. The sample is then submitted to cupellation. This process does not require so much care for gold as silver, as none of this metal is absorbed by the cupel, or lost by evaporation, and it will safely bear the highest heat of the furnace without injury. In other respects the operation may be conducted in exactly the same manner as for silver. (*See No.* 3206.)

Quartation. After gold has passed the cupel, it may still retain either of the other perfect metals, particularly silver. To remove the latter it undergoes the operations of quartation and parting. Quartation is performed by adding 3 parts of silver to one of the cupelled sample, and fusing them together, by which the gold is reduced to one fourth of the mass, or even less; hence the name. In this state nitric acid will dissolve out the silver, which brings us to the next operation. In many cases the operation of quartation is performed conjointly with that of cupellation.

Parting. The alloy of gold and silver formed by quartation is next hammered or rolled out into a thin strip or leaf, curled up into a spiral form, and submitted to the action of nitric acid, specific gravity 1.3, diluted with half its weight of water; this being poured off, another quantity of acid, of about 1.26, and undiluted, may be employed. In each case the acid should be boiled upon the alloy for about a quarter of an hour. In the first case the quantity of fluid should be about 2½ ounces, and in the second 1½ ounces. The second part of the operation of parting is called the *reprise*. If the acid be used too strong it leaves the gold in a state of powder, otherwise the metal preserves its form throughout the process of parting. It is next carefully collected, washed, and dried.

Annealing. The sample of pure gold has now only to be annealed, which is done by putting it into a small porous crucible, and heating it to redness in the muffle.

Weighing. The pure gold is next accurately weighed. This weight doubled (if 12 grains are under assay), or quadrupled (if 6 grains), gives the number of carats fine of the alloy examined, without calculation. The loss of weight by cupellation gives the amount of copper in the sample; that after parting, the amount of silver, deducting, of course, the weight of silver used in the process, which is called the *witness.* When the sample contains but very little gold, the dry method of assaying cannot be depended on, and chemical analysis must be had recourse to. (*Cooley.*)

3192. Assay of Gold by Chemical Analysis. The richness of gold in any substance, whether liquid or solid, especially where the quantity is small, is most easily obtained by chemical analysis. The gold is thrown down from its solution by adding a solution of protosulphate of iron; the precipitate, after being washed, dried and gently heated, may be weighed as pure gold.

If 100 grains of the substance or liquid under test be taken for examination, the weight in grains of the dried precipitate will give the percentage of gold contained in the sample.

3193. To Obtain Gold Chemically Pure. Dissolve gold in nitromuriatic acid (a mixture of 1 part nitric acid with 2 parts muriatic acid, and called aqua regia); by adding to the gold solution a solution of protosulphate of iron, the pure gold is precipitated in the form of a brown powder, which should be thoroughly washed to free it from acid, and then dried. In this form it is ready to mix by fusion with other metals; or the powder can be reduced to solid metallic form by melting in a crucible, with a charcoal fire, sprinkling occasionally into the crucible a little saltpetre and potash as a flux. The gold will form a button at the bottom.

3194. Grain Gold. Cupelled gold, 1 part; silver, 3 parts; melt and pour in a small stream into water; dissolve out the silver with nitric acid, and heat the grains to redness. Used to make preparations of gold.

3195. Liquid Gold. Agitate ether with a solution of terchloride of gold for some time, allow it to repose, and decant the supernatant portion. Naphtha and essential oils possess the same property as ether, of taking gold from its solutions. This liquid was formerly held in great esteem as a cordial medicine. It is now only employed for writing on steel, gilding, &c. As it dries, it leaves a coating of pure gold. (*See No.* 2585.)

3196. To Make Watch Hands Red. Mix to a paste over a lamp, 1 ounce carmine, 1 ounce chloride of silver, and ½ ounce tinners' japan. Put some of the paste on the hands, and lay them face upwards on a sheet of copper, holding it over a spirit lamp until the desired color appears on them.

3197. French Method for Coloring Gold. A solution is made of 2 parts nitre, 1 part Roman alum, and 1 of sea salt. The jewels or articles of gold are kept in the solution at a boiling point for from 15 to 25 minutes; and then washed in water. The surface of the gold is dull, but perfectly uniform, and ready for burnishing.

3198. To Color Gold. Take 1 part salt, 1 part alum, and 2 parts saltpetre; each material to be well pounded separately in a mortar; put them into an iron pot with ¼ pint water, and heat slowly over a fire: boil gently and stir with an iron rod until it rises. It is then ready for the reception of the articles to be colored, which must be not less than 18 carat fine. They are suspended in the color by 18 carat wire, and kept in motion till the liquid begins to sink, then taken out and dipped in aquafortis pickle. The color liquid will rise again, and then another dip, and sometimes two, may be necessary to give the articles the proper color. This process of coloring is no more than taking from the surface the inferior metals, leaving a thin coating of pure gold; its application should not be too long continued, as it also dissolves a small portion of the gold.

3199. Gold Coloring Solution. Take 1 ounce nitrate of soda, and ½ ounce chloride of sodium, and dissolve in a slight excess of warm water, afterwards adding to the solution about 5 drachms hydrochloric acid. The solution should be kept boiling while the work is in it.

3200. To Clean Gold after it is Soldered. Put it through the same process as silver (*see No.* 3222), but, instead of alum-water, boil it in wine and sal-ammoniac.

3201. To Restore the Color of Gold after Soldering. Boil the gold, after soldering, in diluted oil of vitriol; rinse in clean water, polish with Tripoli mixed in oil (sweet oil is best), wash and gloss with crocus on a clean cloth.

3202. To Clean Gold. Dissolve a little muriate of ammonia in urine; boil your soiled gold therein, and it will become clean and brilliant.

3203. To Clean Gold Ornaments. Gold ornaments may also be thoroughly cleaned by immersion for a few seconds in a weak solution of ammonia. Then wash with soap and water.

3204. Polishing Powder for Gold Articles. Dr. W. Hofman has analyzed a polishing powder sold by gold workers in Germany, which always commands a very high price, and hence, it may be inferred, is well adapted for the purpose. He found it to be a very simple composition, being a mixture of about 70 per cent. sesquioxide of iron (iron rust) and 30 per cent. sal-ammoniac. To prepare it, protochloride of iron, obtained by dissolving iron in hydrochloric acid, is treated with liquid ammonia until a precipitate is no longer formed. The precipitate is collected on a filter, and, without washing, is dried at such a temperature that the adhering sal-ammoniac shall not be volatilized. The protoxide of iron precipitate at first becomes charged with sesquioxide.

Silver.

This metal has a very white color, a high degree of lustre, is exceedingly malleable and ductile, and the best conductor of heat and electricity known. It is procured from its ores chiefly by amalgamation and cupellation. Its specific gravity is 10.474, and melting-point 1873° Fahr., or bright redness. It is soluble in nitric acid, and in sulphuric acid by the aid of heat. Its surface is rapidly tarnished by sulphuretted hydrogen, and by the fumes of sulphur.

3206. Assay of Silver by Cupellation. The assay pound (usually 12 or 20 grains for silver) of the alloy for examination is accurately weighed, and then wrapped in a small piece of paper ready to undergo the process of cupellation. (*See No.* 3191.) The quantity of lead used is not uniform, but depends on the nature of the alloy. It should be 16 times the weight of the copper presumed to be present in the sample. This, however, cannot be accurately ascertained, though an experienced assayer is generally able to guess very nearly the amount. If too much lead be used, the button obtained by cupellation will be too small, owing to some of the silver being absorbed by the cupel; and if too little be used, the button will come out too large, from still containing some copper. The importance of justly proportioning the lead to the quantity of copper present in the alloy, cannot be too much insisted on. (*Cooley*).

3207. Assay of Silver by Chemical Analysis. Dissolve 10 grains of the alloy in 100 grains of nitric acid, specific gravity 1.28, by the aid of heat; the solution being made in a tall stoppered glass tube, furnished with a foot; then place it in a very delicate balance, which must be brought into an exact state of equilibrium, and add the test solution (*see No.* 3208) gradually and cautiously, until the whole of the silver be thrown down; but the utmost care must be taken not to exceed this point. The number of grains now required to restore the equilibrium of the scales gives the exact quantity of pure silver present in 1000 parts of the sample. The addition of the test liquor to the solution requires the utmost exactness. After each addition the stopper should be placed in the tube, and the latter violently agitated for a short time, when the liquor will rapidly clear and enable it to be seen when the operation is concluded. We must then, as a check, add a small quantity of a solution of nitrate of silver to the liquor in the tube, after having first carefully taken the weight. If too much of the test liquor has been added, this will produce a fresh precipitate, and the assay cannot then be depended on. Instead of weighing the quantity of test liquor used, a tube graduated into 100 parts, and holding 1000 grains, may be used instead, every division of which required to throw down the silver, will represent the $\frac{1}{10}$th of a grain. The tube being filled to the 0, is ready for use, and from being graduated downward the quantity poured out may at once be read off. Generally speaking, however, measuring does not admit of the same accuracy as weighing. The termination of the operation is clearly marked, when, on adding a minute quantity of the test liquor to the silver solution, no cloudiness occurs.

3208. Test Solution for Assaying Silver. Dissolve 54¼ grains pure sea-salt (*see No.* 3209) in 22 ounces 320¼ grains (avoirdupois) distilled water. Filter and keep in a stoppered bottle for use.

3209. Pure Sea-Salt. Boil together for a few minutes, in a glass vessel, a solution of salt with a little pure bicarbonate of soda; filter; add muriatic acid until the liquor be neutral to litmus and turmeric paper; then evaporate and crystallize.

3210. To Extract Silver from Lead. This is easily done in a small way by melting the mixed metals by a strong heat in the open air. The lead will be converted into litharge, and the silver will sink to the bottom of the crucible. On a large scale, the silver is extracted from the lead by the oxidation of the lead into a reverberatory furnace of a particular construction. A shallow vessel, called a cupel, is filled with ashes, well packed and pounded down, and a cavity cut out for the reception of the nozzle of a bellows, through which air is forcibly driven. When the fire is lighted and the lead is in a state of fusion from the reverberation of the flame, the blast from the bellows is made to play forcibly on the surface, and in a short time a crust of oxide of lead or litharge is formed and driven off to the side of the cupel opposite to the mouth of the bellows, where a shallow aperture is made for it to pass over; another crust of litharge is formed and driven off, and this is repeated until nearly all the lead has been scorified and blown aside. The complete separation of the lead is indicated by the appearance of a brilliant lustre on the convex surface of the melted mass in the cupel, which is occasioned by the removal of the last crust of litharge which covered the silver. If the silver thus abstracted is not sufficiently pure, it is further refined in a reverberatory furnace, being placed in a cupel lined with bone ashes and exposed to an intense heat, so that the lead which escaped oxidation by the first process is converted into litharge, and is absorbed by the ashes of the cupel.

3211. Test for Metallic Silver. The compounds of silver, mixed with carbonate of soda, and exposed on charcoal to the inner flame of a blow-pipe, afford white, brilliant, and ductile metallic globules, without any incrustation of the charcoal. (*See also Assaying.*)

3212. To Obtain Pure Silver. Pure silver is obtained by placing a copper rod in a solution of nitrate of silver, digesting the precipitate in caustic ammonia, and washing with water; or by boiling recently precipitated and still moist chloride of silver in a bright iron vessel along with water. (*See No.* 3536.)

3213. Solvent for Silver. Nitro-sulphuric acid. Dissolve 1 part nitre in 10 parts oil of vitriol. Used for dissolving the silver from plated goods, &c. It dissolves silver at a temperature below 200°, and scarcely acts upon copper, lead, and iron, unless diluted. (*See Nos.* 3716, 3720, *and* 3721.) The silver is precipitated from the solution, after moderately diluting it, by common salt, and the chloride reduced as directed in Nos. 3214 and 3215.

3214. To Purify and Reduce Silver. Silver, as used in the arts and coinage, is alloyed with a portion of copper. To purify it, dissolve the metal in nitric acid slightly diluted, and add common salt, which throws down the whole of the silver in the form of chloride. To reduce it into a metallic state several methods are used. The chloride must be repeatedly washed with distilled water, and placed in a zinc cup; a little diluted sulphuric acid being added, the chloride is soon reduced. The silver, when thoroughly washed, is quite pure. In the absence of a zinc cup, a porcelain cup containing a zinc plate may be used. The process is expedited by warming the cup. (*See No.* 3536.)

3215. To Purify and Reduce Silver. Proceed as above, and digest the washed chloride with pure copper and ammonia. The quantity of ammonia need not be sufficient to dissolve the chloride. Leave the mixture for a day, then wash the silver thoroughly. Or: Boil the washed and moist chloride in solution of pure potash, adding a little sugar; when washed it is quite pure.

3216. Peale's Method of Obtaining Pure Silver from its Solutions. By adding in excess, a saturated solution of common salt to the solution of nitrate of silver, the metal is thrown down, as an insoluble salt, the chloride of silver. The precipitate must then be carefully washed until it is entirely freed from the presence of nitric acid. Granulated zinc must then be added to the chloride, and stirred through the mass. The finer the zinc has been granulated, the more rapid will be the reduction. Dilute sulphuric acid must also be added, and the whole stirred until the reduction is complete, which will be known by the entire disappearance of the white chloride, and its conversion into a grey powder. A new set of affinities takes place with great rapidity in this combination, and the chlorine is liberated from the silver, which takes its metallic form, as above stated, in the appearance of a grey powder. The zinc, having been added in excess, must now be removed by the addition of dilute sulphuric acid; after all action has ceased, the solution of zinc must be decanted, or drawn off with a syphon, and the silver washed until free from acidulous matter, after which it may be dried by pressure, or the simple application of heat in a pan over the fire, when it will be ready for melting, with the usual fluxes, or re-solution with nitric acid. This process is rapid and easy; is not subject to loss; it will yield, in the terms of trade, pure silver, of a quality from 994 to 998 thousandths fine, and is therefore well adapted to the preparation of pure nitrate of silver for the use of photographers and all others who need a reliable article.

3217. Silver Dust. Take silver, dissolve it in slightly diluted nitric acid, and precipitate it with slips of *bright* copper; wash the powder in spirits, and dry it. Or: An exceedingly fine silver dust may be obtained by boiling recently precipitated chloride of silver with water acidulated with sulphuric acid, and zinc.

3218. To Frost Polished Silver. To produce a frosted surface on polished silver, use cyanide of potassium with a brush. The silver should not be handled during the process, but held with pliers made of lancewood or boxwood. The proportion should be 1 ounce dissolved in ½ pint of water. It is very poisonous.

3219. To Oxidize Silver. A very beautiful effect is produced upon the surface of silver articles, technically termed oxidising, which gives the surface an appearance of polished steel. This can be easily effected by taking a little chloride of platinum, prepared as described in the next receipt, heating the solution and applying it to the silver when an oxidized surface is required, and allowing the solution to dry upon the silver. The darkness of the color produced varies according to the strength of the platinum solution, from a light steel gray to nearly black. The effect of this process, when combined with what is termed dead work, is very pretty, and may be easily applied to medals, giving scope for the exercise of taste. The high appreciation in which ornaments in oxidized silver are now held, render a notice of the process followed interesting. There are two distinct shades in use—one produced by chloride, which has a brownish tint, and the other by sulphur, which has a bluish-black tint. To produce the former, it is only necessary to wash the article with a solution of sal-ammoniac; a much more beautiful tint may, however, be obtained by employing a solution composed of equal parts of sulphate of copper and sal-ammoniac in vinegar. The fine black tint may be produced by a slightly warm solution of sulphuret of potassium or sodium. (*Dr. Ellsner.*)

3220. To Prepare Nitro-Muriate (Chloride) of Platinum. The nitro-muriate of platinum is easily prepared: Take 1 part nitric acid, and 2 parts hydrochloric (muriatic) acid; mix together and add a little platinum; keep the whole at or near a boiling heat; the metal is then dissolved, forming the solution required.

3221. To Make a Silver Tree. Dissolve 20 grains nitrate of silver in 1 fluid ounce of water in a phial, and add ½ drachm pure mercury. Arrange the zinc as for the lead tree. Very brilliant and beautiful.

3222. To Clean Silver after it is Soldered. Make it just red hot, and let it cool; then boil it in alum water, in an earthen vessel, and it will be as clean as when new.

3223. Belgian Burnishing Powder. A burnishing powder in use in Belgium is composed of ¼ pound fine chalk, 3 ounces pipe clay, 2 ounces white lead, ¾ ounce magnesia (carbonate), and the same quantity of jeweler's rouge.

3224. To Protect Silver-Ware from Tarnishing. The loss of silver which results from the impregnation of our atmosphere with sulphur compounds, especially where gas is burned, is very great. Silversmiths may thank one of their confraternity—Mr. Strolberger, of Munich—for a happy thought. He seems to have tried various plans to save his silver, if possible. He covered his goods with a clear white varnish, but found that it soon turned yellow in the window, and spoiled the look of his wares. Then he tried water-glass (solution of silicate of potash), but this did not answer. He tried some other solutions, to no purpose; but at last he hit upon the expedient of coating his goods over with a thin coating of collodion, which he found to answer perfectly. No more loss of silver, and no longer incessant labor in keeping it clean. The plan he adopts is this: He first warms the articles to be coated, and then paints them over carefully with a thinnish collodion diluted with alcohol, using a wide soft brush for the purpose. Generally, he says, it is not advisable to do them over more than once. Silver goods, he tells us, protected in this way, have been exposed in his window more than a year, and are as bright as ever, while others unprotected have become perfectly black in a few months.

3225. To Prevent Coins and Small Ornaments from Tarnishing. All ornaments, whether gold or silver, can be kept from tarnishing if they are carefully covered from the air in box-wood sawdust, which will also dry them after being washed. The tarnish on silver-ware is most often due to sulphur. A gentleman who wears a silver watch finds that it is tarnished from the sulphur fumes of the rubber ring which holds together his ferry tickets. Sulphur fumes enough get into the air to account for all ordinary cases of tarnishing.

3226. To Clean Silver. Immerse for half an hour the silver article into a solution made of 1 gallon water, 1 pound hyposulphite of soda, 8 ounces muriate of ammonia, 4 ounces liquid ammonia, and 4 ounces cyanide of potassium; but, as the latter substance is poisonous, it can be dispensed with if necessary. The article, being taken out of the solution, is washed, and rubbed with a wash leather.

3227. To Clean Silver Plate. Fill a large saucepan with water; put into it 1 ounce carbonate of potash and ½ pound whiting. Now put in all the spoons, forks, and small plate, and boil them for 20 minutes; after which take the saucepan off the fire and allow the liquor to become cold; then take each piece out and polish with soft leather. A soft brush must be used to clean the embossed and engraved parts.

3228. Plate Boiling Powder. Mix equal parts of cream of tartar, common salt, and alum. A little of this powder, added to the water in which silver-plate is boiled, gives to it a silvery whiteness.

3229. Plate Cleaning Powder. For cleaning silver and plated articles, &c. Mix ½ pound jeweler's rouge with ¾ pound prepared chalk. Or: ½ pound levigated putty powder, ½ pound burnt hartshorn, 1 pound prepared chalk, and 1 ounce rose-pink.

3230. To Clean Silver. To clean silver, mix 2 tea-spoonfuls of ammonia in a quart of hot soap-suds. Put in the silver-ware and wash it, using an old nail-brush or tooth-brush for the purpose.

3231. To Clean Silver and Silver Plated Articles. Boil 1 ounce finely powdered and calcined hartshorn in 1 quart water, and while on the fire, insert the articles, as many as the vessel will hold; leave them in a short time, then take them out, and dry them over a fire; when all the articles have been thus treated, put into the solution clean woolen rags; when they are saturated, hang them up to dry. These will be excellent for polishing the silver, as well as for cleaning brass door-knobs, &c.

3232. To Preserve the Polish on Silver. Wash it twice a week (if in daily use) with *soft* soap and hot water, and polish with Canton flannel. (*See next receipt.*)

3233. To Clean Silver Ornaments. Boil them in soft soap and water for five minutes; then put them in a basin with the same hot soap and water, and scrub them gently with a very soft brush while hot; then rinse and dry with a linen rag. Heat a piece of common unglazed earthenware, or a piece of brick or tile in the fire; take it off, and place the ornaments upon it for the purpose of drying them, and causing every particle of moisture to evaporate; as the moisture, which otherwise would remain on the silver, will cause it to tarnish, or assume a greenish hue.

3234. To Clean Silver. Moisten some finely powdered whiting or Paris white with spirits of hartshorn, rub the silver into it, let it dry, then rub it off with a soft cloth and polish it with chamois leather. Some kinds of silver soap keep silver looking nicely, but many of them are chemical compounds that injure the silver.

3235. To Clean Silver Plate. Whiting finely powdered and moistened with a little sweet oil is excellent to clean silver. Let the mixture dry on, then rub it off with a soft linen cloth and polish with chamois leather. This gives silver a beautiful white appearance, and if well done the silver will keep clean a long time.

3236. To Remove Ink Stains from Silver. The tops and other portions of silver inkstands frequently become deeply discolored with ink, which is difficult to remove by ordinary means. It may, however, be completely eradicated by making a little chloride of lime into a paste with water, and rubbing it upon the stains.

3237. To Remove Dark Stains from Silver. A certain remedy for the most inveterate stains that are sometimes to be seen on teaspoons and other silver ware, is to pour a little sulphuric acid into a saucer, wet with it a soft linen rag, and rub it on the blackened silver till the stain disappears. Then coat the articles with whiting finely powdered and sifted, and mixed with whiskey or spirits of wine. When the whiting has dried on, and rested a quarter of an hour or more, wipe it with a silk handkerchief, and polish with a soft buckskin.

3238. To Remove Egg Stains from Spoons. To remove the stains on spoons, caused by using them for boiled eggs, take a little common salt moist between the thumb and finger, and briskly rub the stain, which will soon disappear. Then wash.

3239. To Clean Gold, Silver, and Copper Coin for Numismatic Collections. Make a weak solution of cyanide of potassium and bathe the coin in it for 2 or 3 seconds, then immediately wash it with a *very fine* brush, in soap-suds; rinse in clean cold water, and dry in boxwood saw dust. This receipt is particularly good for fine proof coins. Be careful not to let the coins remain in the solution longer than the time specified, otherwise they may have a frosted appearance. (*See No.* 2167.) As the cyanide of potassium is a very deadly poison, great care must be taken by the operator not to use it unless his hands are entirely free from scratches. This solution may also be used for cleaning fine copper coins, but care must be taken not to use the mixture that has previously been employed for cleaning silver, or a coating of the latter metal may be the consequence. (*See Nos.* 3224 *and* 3225.)

Silver coins are often covered with a dense green oxide. To remove this they should be steeped for 10 minutes in a solution of ammonia, then immersed in water and wiped with a soft towel; if necessary, a fresh quantity of the solution may be applied. Copper coin may be cleaned by immersing in pure sweet oil and wiping dry with a soft rag.

Copper. This metal is found in the metallic state, and in combination with oxygen, sulphur, acids, and other minerals, and in the organic kingdom, in the ashes of plants, and in the blood of animals. The copper of commerce is principally prepared from copper pyrites, a mixed sulphuret of iron and copper, found in Cornwall and other parts of the world. Copper is only prepared from its ores on the large scale. The copper pyrites are first roasted, and then smelted, by which process *coarse metal* is produced; this is again submitted to calcination and smelting, when *fine metal* is obtained. It afterwards undergoes the process of refining and toughening. This metal is malleable and ductile. It has a specific gravity of 8.8 to 8.9, fuses at about 2000° Fahr., and volatilizes at higher temperatures. It is easily soluble in nitric acid, and is attacked more or less rapidly by acids in general. It forms numerous compounds, all of which are more or less poisonous. Exposure to a damp atmosphere produces on its surface a green colored oxide, known as *verdigris*. Copper may be readily alloyed with other metals, except iron and lead, with which it unites with difficulty.

3241. Test for the Quantity of Copper in a Compound. The quantity of copper present in any compound may be estimated by throwing it down from its solution by pure potassa, after which it must be carefully collected, washed, dried, ignited, and weighed. This will give the quantity of the oxide from which its equivalent of metallic copper may be calculated; every 5 parts of the former being nearly equal to 4 of the latter; or, more accurately, every 39.7 parts are equal to 31.7 of pure metallic copper. Copper may also be precipitated at once in the metallic state, by immersing a piece of polished steel into the solution; but this method will not give very accurate results.

3242. To Separate Lead from Copper. Copper may be separated from lead by adding sulphuric acid to the nitric solution, and evaporating to dryness, when water digested on the residuum will dissolve out the sulphate of copper, but leave the sulphate of lead behind. From this solution the oxide of copper may be thrown down as before.

3243. To Separate Zinc from Copper. Copper may be separated from zinc by sulphuretted hydrogen, which will throw down a sulphuret of copper, which may be dissolved in nitric acid, and treated as in last receipt.

3244. To Separate Tin from Copper. Digest in nitric acid; the copper will be dissolved, but the tin will remain in an insoluble peroxide.

3245. To Separate Silver from Copper. Digest, in a state of filings or powder, in a solution of chloride of zinc, which dissolves the copper and leaves the silver unchanged.

3246. To Separate Copper from its Alloys. Copper may be separated in absolute purity from antimony, arsenic, bismuth, lead, iron, &c., as it exists in bell-metal, brass, bronze, and other commercial alloys, by fusing, for about half an hour, in a crucible, 10 parts of the metal with 1 part each of copper scales (black oxide), and bottle glass. The pure copper is found at the bottom of the crucible, whilst the other metals or impurities are either volatilized or dissolved in the flux.

3247. Copper in Fine Powder. A solution of sulphate of copper is heated to the boiling-point, and precipitated with sublimated zinc. (*See No.* 30.) The precipitated copper is then separated from the adherent zinc by diluted sulphuric acid, and dried by exposure to a moderate temperature.

3248. Reduction of Copper in Fine Powder. M. Schiff gives the following process for obtaining copper in a state of fine division: A saturated solution of sulphate of copper, together with some crystals of the salt, are introduced into a bottle or flask, and agitated with some granulated zinc. The zinc displaces the copper from its solution, fresh sulphate dissolving as the action goes on, until the whole is exhausted. Heat is disengaged during the operation. The precipitated copper must be washed and dried as rapidly as possible, to prevent oxidation.

3249. Feather-Shot Copper. Melted copper, poured in a small stream into cold water. It forms small pieces, with a feathered edge, hence the name. It is used to make solution of copper.

3250. Welding Copper. A compound of 358 parts phosphate of soda and 124 parts boracic acid is prepared, and is used when the metal is at a dull red heat; the heat is then increased till the metal becomes of a cherry red color, and the latter is at once hammered. A hammer of wood is recommended for this purpose, as the metal is liable to soften at a high heat; and the hammer should be used cautiously. All scale and carbonaceous matter must be removed from the surface of the copper, as the success of the welding depends on the formation of an easily fusible phosphate of copper, which would be reduced to a phosphide by the presence of carbon.

3251. To Prevent the Corrosion of Copper and Other Metals. The best means of preventing corrosion of metals is to dip the articles first into a very dilute nitric acid, immerse them afterwards in linseed oil, and allow the excess of oil to drain off. By this process metals are effectually prevented from rust or oxidation.

3252. To Clean Coppers and Tins. These are cleaned with a mixture of rotten stone, soft soap, and oil of turpentine, mixed to the consistency of stiff putty. The stone should be powdered very fine and sifted; and a quantity of the mixture may be made sufficient to last for a long while. The articles should first be washed with hot water, to remove grease. Then a little of the above mixture, mixed with water, should be rubbed over the metal; then rub off briskly, with dry clean rag or leather, and a beautiful polish will be obtained. When tins are much blackened by the fire they should be scoured with soap, water, and fine sand.

Lead. Lead is only prepared on the large scale. It is usually extracted from *galena*, a natural sulphuret of lead, by roasting the ore in a reverberatory furnace, and afterwards smelting it along with coal and lime. Its specific gravity, in a state of absolute purity, is 11.38 to 11.44, but ordinary lead seldom exceeds 11.35. It melts at about 612° Fahr., and when very slowly cooled, crystallizes in octohedrons. It is malleable and ductile, but devoid of elasticity. Lead is not dissolved by muriatic, sulphuric, or the vegetable acids, unless by free contact with air, and then very slowly: but nitric acid rapidly oxidizes it, forming a solution of nitrate of lead. Pure water, put into a leaden vessel, and exposed to the air, soon corrodes it, and dissolves the newly-formed oxide; but river and spring water exert no such influence, the carbonates and sulphates in such water destroying its solvent power. Lead may be alloyed with most metals, except those which differ greatly from it in specific gravity and melting point. It has a strong affinity for gold and silver, and is therefore employed to separate those metals, by cupellation, from other metals and minerals.

3254. Cautions on the Use of Lead for Cisterns, &c. Ordinary water, which abounds in mineral salts, may be safely kept in leaden cisterns; but distilled and rain water, and water that contains scarcely any saline matter, speedily corrode, and dissolve a portion of lead, when kept in vessels of that metal. When, however, leaden cisterns have iron or zinc fastenings or braces, a galvanic action is set up, the preservative power of saline matter ceases, and the water speedily becomes contaminated with lead. Water containing free carbonic acid also acts on lead; and this is the reason why the water of some springs, kept in leaden cisterns, or raised by leaden pumps, possesses unwholesome properties. Free carbonic acid is evolved during the fermentation or decay of vegetable matter, and hence the propriety of preventing the leaves of trees falling into water-cisterns formed of lead.

3255. To Test the Richness of Lead Ores. Lead ores, or galena, may be tested in different ways. The *wet way* is as follows: Digest 100 grains of the ore in sufficient nitric acid diluted with a little water, apply heat to expel any excess of acid, and largely dilute the remainder with distilled water. Next add dilute hydrochloric acid, by drops, as long as it occasions a precipitate, and filter the whole, after being moderately heated, upon a small paper filter. Treat the filtered liquid with a stream of sulphuretted hydrogen; collect the black precipitate, wash it, and digest it in strong nitric acid; when entirely dissolved, precipitate the lead with sulphuric acid dropped in it, evaporate the precipitate to dryness, the excess of sulphuric acid being expelled by a rather strong heat applied towards the end. The dry mass should be washed, dried, and exposed to slight ignition in a porcelain crucible. The resulting dry sulphate is equal to .68 per cent. of its weight in lead.

3256. To Find the Percentage of Lead in Lead Ores. This can be done by applying the test in the *wet way* (*see No.* 3255), and multiplying the weight of the product obtained in grains by .68. It may also be found in the *dry way*, as follows: Plunge a conical wrought iron crucible into a blast furnace, raised to as high a heat as possible; when the crucible has become of a dull red heat, introduce into it 1000 grains galena (lead ore) reduced to powder, and stir it gently with a piece of stiff iron wire flattened at the end. This wire must never be suffered to get red hot. To prevent the ore from adhering, after 3 or 4 minutes, cover up the crucible; and when at a full cherry-red heat, add 2 or 3 spoonfuls of reducing flux (*see No. 3464*), and bring to a full white heat; in 12 to 15 minutes, after having scraped down the scoria, etc., from the sides of the crucible, into the melted mass, the crucible should be removed from the fire, and the contents tilted into a small brass mould, observing to run out the metal free from scoria, by raking the latter back with a piece of green wood. The scoria is then reheated in the crucible with ½ spoonful of flux, and this second reduction added to the first. The weight in grains of the metal obtained, divided by 10, gives the percentage of metallic lead in the sample of ore.

3257. To Make a Lead Tree. Dissolve 1 ounce sugar of lead (acetate of lead) in 1½ pints distilled water; add a few drops of acetic acid; place the liquid in a clear white glass bottle and suspend a piece of zinc in it by means of a fine thread secured to the cork.

Iron.

Iron is only prepared on the large scale. It is obtained by smelting the ore along with coke and a flux (either limestone or clay). The crude iron thus obtained is run into moulds, and then constitutes *cast iron or pig iron*. By the subsequent process of refining, (puddling, welding,) it is converted into *soft iron or wrought iron*. The properties and uses of iron are too well known to require description. Its applications in almost every branch of human industry are almost infinite. It is remarkably ductile, and possesses great tenacity, but it is less malleable than many of the other metals. Its specific gravity is 7.788, and melts at about 2700° Fahr. It is the hardest of all of the malleable and ductile metals, and when combined with carbon or silica (steel), admits of being tempered to almost any degree of hardness or elasticity. Metallic iron is distinguished by being attracted by the magnet; by being dissolved by dilute muriatic and sulphuric acids, with solution of hydrogen gas, recognized by its inflammability; and the solution exhibits the usual reactions of protoxide of iron. (*Cooley.*) Iron does not alloy easily with other metals, principally on account of its high melting point. It is easily attacked by acids, and requires protection from the air, to prevent oxidization or rusting.

3259. To Estimate the Percentage of Iron in Ores. Prepare a crucible of refractory clay by pressing into it successive layers of moistened powdered charcoal until full and solid; clear out a cavity by removing the central portion. Take 200 grains of the powdered ore, and mix it with the same weight of dry slacked lime, and 50 grains charcoal; if necessary a litte carbonate of soda may be used with very refractory ores; introduce this mixture into the crucible and lute it up. Expose the crucible to a moderate heat until the contents of the crucible are dry, then apply, and maintain for half an hour the full heat of a blast furnace. Then remove the crucible, tap it steadily on the edge of the furnace, so as to bring the metallic portion of its contents together at the bottom; and, when cool, break the crucible open. The iron will be found in a clean button at the bottom of the slag. Clean the iron with a scratch brush, and weigh it. Its weight, divided by 2, will give the percentage of richness of the ore under examination.

3260. To Distinguish Wrought and Cast Iron from Steel. Elsner produces a bright surface by polishing or filing, and applies a drop of nitric acid, which is allowed to remain there for one or two minutes, and is then washed off with water. The spot will then look a pale ashy gray on wrought iron, a brownish black on steel, a deep black on cast iron. It is the carbon present in various proportions which produces the difference in appearance.

3261. To Impart to Cast Iron the Appearance of Bronze. The article to be so treated is first cleaned with great care, and then coated with a uniform film of some vegetable oil; this done, it is exposed in a furnace to the action of a high temperature, which, however, must not be strong enough to carbonize the oil. In this way the cast iron absorbs oxygen at the moment the oil is decomposed, and there is formed at the surface a thin coat of brown oxide, which adheres very strongly to the metal, and will admit of a high polish, giving it quite the appearance of the finest bronze.

3262. Brown Tint for Iron and Steel. Dissolve in 4 parts of water, 2 parts crystallized chloride of iron, 2 parts chloride of antimony, and 1 part gallic acid, and apply the solution with a sponge or cloth to the article, and dry it in the air. Repeat this any number of times according the depth of color which it is desired to produce. Wash with water, and dry, and finally rub the articles over with boiled linseed oil. The metal thus receives a brown tint and resists moisture. The chloride of antimony should be as little acid as possible.

3263. To Blue Gun Barrels. Apply nitric acid and let it eat into the iron a little; then the latter will be covered with a thin film of oxide. Clean the barrel, oil, and burnish.

3264. To Ornament Gun Barrels. A very pretty appearance is given to gun barrels by treating them with dilute nitric acid and vinegar, to which has been added sulphate of copper. The metallic copper is deposited irregularly over the iron surface. Wash, oil, and rub well with a hard brush.

3265. Iron Filings. The only way to obtain them pure, is to act on a piece of soft iron with a file.

3266. To Remove Rust from Iron. We have never seen any iron so badly scaled or incrusted with oxide, that it could not be cleaned with a solution of 1 part sulphuric acid in 10 parts water. Paradoxical as it may seem, strong sulphuric acid will not attack iron with anything like the energy of a solution of the same. On withdrawing the articles from the acid solution they should be dipped in a bath of hot lime water, and held there till they become so heated that they will dry immediately when taken out. Then, if they are rubbed with dry bran or sawdust, there will be an almost chemically clean surface left, to which zinc will adhere readily.

3267. To Keep Polished Iron Work Bright. Common resin melted with a little gallipoli oil and spirits of turpentine has been found to answer very well for preserving polished iron work bright. The proportions should be such as to form a coating which will adhere firmly, not chip off, and yet admit of being easily detached by cautious scraping.

3268. To Protect Iron from Oxidization. Among the many processes and preparations for preserving iron from the action of the atmosphere, the following will be found the most efficient in all cases where galvanization is impracticable; and, being unaffected by sea water, it is especially applicable to the bottoms of iron ships, and marine work generally: Sulphur, 17 pounds; caustic potash lye of 35° Baumé, 5 pounds; and copper filings, 1 pound. To be heated until the copper and sulphur dissolve. Heat, in another vessel, tallow, 750 pounds, and turpentine, 150 pounds, until the tallow is liquefied. The compositions are to be mixed and stirred together while hot, and may be laid on to the iron, in the same way as paint.

3269. To Protect Iron from Rust. A mastic or covering for this purpose, proposed by M. Zeni, is as follows: Mix 80 parts pounded brick, passed through a silk sieve, with 20 parts litharge; the whole is then rubbed up by the muller with linseed oil, so as to form a thick paint, which may be diluted with spirits of turpentine. Before it is applied the iron should be well cleaned. From an experience of 2 years upon locks exposed to the air, and watered daily with salt water, after being covered with 2 coats of this mastic, the good effects of it have been thoroughly proved.

3270. To Prevent the Decay of Iron Railings. Every one must have noticed the destructive combination of lead and iron, from railings being fixed in stone with the former metal. The reason for this is, that the oxygen of the atmosphere keeps up a galvanic action between the two metals. This waste may be prevented by substituting zinc for lead, in which case the galvanic influence would be inverted; the whole of its action would fall on the zinc; the one remaining uninjured, the other nearly so. Paint formed of the oxide of zinc, for the same reason preserves iron exposed to the atmosphere infinitely better than the ordinary paint composed of the oxide of lead.

3271. To Scour Cast Iron, Zinc, or Brass. Cast iron, zinc, and brass surfaces can be scoured with great economy of labor, time and material, by using either glycerine, stearine, naphthaline, or creosote, mixed with dilute sulphuric acid.

3272. To Clean Steel and Iron. Make 1 ounce soft soap and 2 ounces emery into a paste; rub it on the article with wash-leather and it will have a brilliant polish. Kerosene oil will also clean steel.

Steel.

The addition of a small quantity of carbon greatly increases the hardness and tenacity of iron, and converts it into steel. The amount of carbon to be added, should be just that which will produce the maximum of hardness and toughness, without rendering it brittle; ordinary steel contains about 1 per cent. of carbon; hard steel 1.6 to 1.7 per cent. The percentage of carbon in English steel is estimated by Berthier to be 1.87. It melts at about 2500° Fahr.

3274. To Convert Iron into Steel. This is usually done by the process of *cementation*, producing what is termed *blistered steel*. At the bottom of a trough about 2 feet square and 14 feet long, usually formed of fire clay, is placed a layer, about 2 inches thick, of a cement composed of 10 parts charcoal and 1 part ashes and common salt; upon this is laid a tier of thin iron bars about ¼ inch apart; between and over them, a layer of cement is spread, then a second row of bars, and so on, alternately, until the trough is nearly full; lastly a layer of cement covered with moist sand and a close cover of fire-tiles, so as to exclude the air. The trough is exposed to the heat of a coal fire, until a full red heat, about 2000° Fahr., is obtained and kept up steadily for about 7 days. A hole is left in the end of the trough, to allow of a bar being drawn out for examination. When a bar, on being withdrawn and broken, has acquired a crystalline texture, the metal is allowed to cool down gradually, some days being allowed for this, and the charge, when cool, withdrawn from the trough. The bars will be found covered with large blisters, hence the name of the process, and increased about $\frac{1}{130}$ in weight. The steel is now sufficiently good for files and coarser tools, but for finer instruments, several varieties of finer steel are required. (*Makins*).

3275. To Make Shear-Steel. This is produced by cutting up bars of *blistered steel*, into lengths of 30 inches, and binding them in bundles of 8 or 9 by a ring of steel, a rod being fixed for a handle. These are brought to a welding heat, and welded together under a tilt hammer. The binding ring is then removed; and, after reheating, the mass is forged solid, and extended into a bar. In cases where this operation is repeated, the steel is called *double-shear steel*. (*Makins.*)

3276. To Make Cast-Steel. Cast-steel is the best variety for all fine cutting tools. This is a mixture of scraps of different varieties of *blistered* steel, collected together in a good refractory clay crucible; upon this a cover is luted, and it is exposed to an intense heat in a blast furnace for 3 or 4 hours. The contents are then run into moulds. After being subjected to the blows of a tilt-hammer, the cast steel is ready for use. (*Makins*).

3277. Steel Made from Iron Scraps. Take iron scraps in small pieces, put 40 pounds in a crucible, with 8 ounces charcoal, and 4 ounces black oxide of manganese; expose the whole $1\frac{1}{2}$ hours to a high heat, and run into moulds.

3278. To Blue Steel. The mode employed in blueing steel is merely to subject it to heat. The dark blue is produced at a temperature of 600°, the full blue at 560°, and the blue at 550°. The steel must be finely polished on its surface, and then exposed to a uniform degree of heat. Accordingly, there are three ways of coloring: first, by a flame producing no soot, as spirit of wine; secondly, by a hot plate of iron; and thirdly, by wood ashes. As a very regular degree of heat is necessary, wood ashes for fine work bear the preference. The work must be covered over with them, and carefully watched; when the color is sufficiently heightened, the work is perfect. This color is occasionally taken off with a very dilute muriatic acid.

3279. To Blue Small Steel Articles. Make a box of sheet iron, fill it with sand, and subject it to a great heat. The articles to be blued must be finished and well polished. Immerse the articles in the sand, keeping watch of them until they are of the right color, when they should be taken out, and immersed in oil.

3280. To Make Edge-Tools from Cast-Steel and Iron. This method consists in fixing a clean piece of wrought iron, brought to a welding heat, in the centre of a mould, and then pouring in melted steel, so as entirely to envelop the iron; and then forging the mass into the shape required.

3281. To Remove Scale from Steel. Scale may be removed from steel articles by pickling in water with a little sulphuric acid in it, and when the scale is loosened, brushing with sand and a stiff brush.

3282. To Restore Burnt Cast-Steel. Take $1\frac{1}{2}$ pounds borax, $\frac{1}{2}$ pound sal-ammoniac, $\frac{1}{2}$ pound prussiate of potash, 1 ounce resin. Pound the above fine, add a gill each of water and alcohol. Put in an iron kettle, and boil until it becomes a paste. Do not boil too long, or it will become hard on cooling.

3283. To Anneal Steel. For a small quantity. Heat the steel to a cherry red in a charcoal fire, then bury it in sawdust, in an iron box, covering the sawdust with ashes. Let it stay until cold. For a larger quantity, and when it is required to be very soft, pack the steel with cast-iron (lathe or planer) chips in an iron box, as follows: Having at least $\frac{1}{2}$ or $\frac{3}{4}$ inch in depth of chips in the bottom of box, put in a layer of steel, then more chips to fill spaces between the steel, and also the $\frac{1}{2}$ or $\frac{3}{4}$ inch space between the sides of box and steel, then more steel; and, lastly, at least 1 inch in depth of chips, well rammed down on top of the steel. Heat to and keep at a red heat for from 2 to 4 hours. Do not disturb the box until cold.

3284. Engraving Mixture for Writing on Steel. Sulphate of copper, 1 ounce; sal-ammoniac, $\frac{1}{2}$ ounce; pulverize separately, adding a little vermilion to color it, and mix with $1\frac{1}{2}$ ounces vinegar. Rub the steel with soft soap and write with a clean hard pen, without a slit, dipped in the mixture.

3285. Tempering Tools. The steel is generally first hardened by heating it to a cherry red, and then plunging it into cold water. Afterward the temper is drawn by moderately heating the steel again. Different degrees of hardness are required for different purposes.

For very pale straw color, 430°, for lancets.

A shade of darker yellow, 450°, for razors and surgical instruments.

Darker straw yellow, 470°, for pen-knives.

Still darker yellow, 490°, chisel for cutting iron.

Brown yellow, 500°, axes and plane-irons.

Yellow, slightly tinged with purple, 520°, table-knives and watch-springs.

3286. To Temper Drills. Heat the best steel to a cherry red, and hammer until nearly cold, forming the end into the requisite flattened shape, then heat it again to a cherry red, and plunge it into a lump of resin or into quicksilver. A solution of cyanide of potassium in rain water is sometimes used for the tempering plunge bath, but it is not as good as quicksilver or resin.

3287. To Temper Gravers. These may be tempered in the same way as drills; or the red hot instrument may be pressed into a piece of lead, in which a hole about $\frac{1}{4}$ an inch deep has been cut to receive the graver; the lead melting around and enclosing it will give it an excellent temper.

3288. To Temper Spiral Springs. Heat to a cherry red in a charcoal fire, and harden in oil. To temper, blaze off the oil 3 times, the same as for flat springs.

3289. To Temper Old Files. Grind out the cuttings on one side, until a bright surface is obtained; then damp the surface with a little oil, and lay the file on a piece of red-hot iron, bright side upwards. In about a minute the bright surface will begin to turn yellow; and when the yellow has deepened to about the color of straw, plunge in cold water.

3290. To Make Polished Steel Straw Color or Blue. The surface of polished steel acquires a pale straw color at 460° Fahr., and a uniform deep blue at 580° Fahr.

3291. To Temper Mill Picks. After working the steel carefully, prepare a bath of lead heated to the boiling point, which will be indicated by a slight agitation of the surface. In it place the end of the pick to the depth of $1\frac{1}{2}$ inches, until heated to the temperature of the lead, then plunge immediately in clear cold water. The temper will be just right, if the bath is at the temperature required. The principal requisites in making mill picks are: First, get good steel. Second, work it at a low heat; most blacksmiths injure steel by overheating. Third, heat for tempering without direct exposure to the fire. The lead bath acts merely as protection against the heat, which is almost always too great to temper well.

3292. Bath for Hardening Mill Picks. Take 2 gallons rain water, 1 ounce corrosive sublimate, 1 of sal-ammoniac, 1 of saltpetre, $1\frac{1}{2}$ pints rock salt. The picks should be heated to a cherry red, and cooled in the bath. The salt gives hardness, and the other ingredients toughness to the steel; and they will not break, if they are left without drawing the temper.

3293. Composition for Tempering Cast-Steel Mill Picks. To 3 gallons of water, add 3 ounces each nitric acid, spirits of hartshorn, sulphate of zinc, sal-ammoniac, and alum; 6 ounces salt, with a double handful of hoof-parings; the steel to be heated a dark cherry red. It must be kept corked tight to prevent evaporation.

3294. Tempering Steel. Mr. N. P. Ames, late of Chicopee, Mass., after expending much time and money in experiments, found that the most successful means of tempering swords and cutlasses that would stand the United States Government test, was by heating in a charcoal fire, hardening in pure spring water, and drawing the temper in charcoal flame. (*See No.* 3285.)

3295. To Straighten Hardened Steel. To straighten a piece of steel already hardened and tempered, heat it lightly, not enough to draw the temper, and you may straighten it on an anvil with a hammer, if really not dead cold. It is best, however, to straighten it between the centres of a lathe, if a turned article, or on a block of wood with a mallet. Warm, it yields readily to the blows of the mallet, but cold, it would break like glass.

3296. To Restore the Power of Horseshoe Magnets. To restore horseshoe magnets that have lost their power from disuse, proceed as with new ones. Place the poles of the magnet to be charged, against the poles of another, making opposite poles meet. Then draw a piece of soft iron, placed at right angles upon the magnet to be charged, from the poles to the bend. Do this a number of times on each side of the magnet. If the magnet is of good steel, this produces a maximum power. It is the method of Jacobi, and is considered one of the best.

3297. Case-Hardening is the operation of giving a surface of steel to pieces of iron, by which they are rendered capable of receiving great external hardness, while the interior portion retains all the toughness of good wrought-iron. This is accomplished by heating the iron in contact with animal carbon, in close vessels. George Ede says:—The articles intended to be case-hardened are put into the box with animal carbon, and the box made air-tight by luting it with clay. They are then placed in the fire and kept at a light red heat for any length of time, according to the depth required. In half an hour after the box and its contents have been heated quite through, the hardness will scarcely be the thickness of a half dime; in an hour, double; and so forth, till the desired depth is acquired. The box is then taken from the fire, and the contents emptied into pure cold water. They can then be taken out of the water and dried (to keep them from rusting), by riddling them in a sieve with some dry saw-dust; and they are then ready for polishing. Case-hardening is a superficial conversion of iron into steel. It is not always merely for economy that iron is case-hardened, but for a multitude of things it is preferable to steel, and answers the purpose better. Delicate articles, to keep from blistering while heating, may be dipped into a powder of burnt leather, or bones, or other coaly animal matter.

3298. To Case-Harden with Charcoal. The goods, finished in every respect but polishing, are put into an iron box, and covered with animal or vegetable charcoal, and cemented at a red heat, for a period varying with the size and description of the articles operated on.

3299. Moxon's Method of Case-Hardening. Cow's horn or hoof is to be baked or thoroughly dried, and pulverized, in order that more may be got into the box with the articles. Or bones reduced to dust answer the same purpose. To this add an equal quantity of bay salt; mix them with stale chamberlye, or white wine vinegar; cover the iron with this mixture, and bed it in the same in loam, or enclose it in an iron box; lay it on the hearth of the forge to dry and harden; then put it into the fire, and blow till the lump has a blood-red heat, and no higher, lest the mixture be burnt too much. Take the iron out, and immerse it in water.

3300. To Case-Harden. Make a paste with a concentrated solution of prussiate of potash and loam, and coat the iron therewith; then expose it to a strong red heat, and when it has fallen to a dull red, plunge the whole into cold water.

3301. To Case-Harden Polished Iron. The iron, previously polished and finished, is to be heated to a bright red and rubbed or sprinkled over with prussiate of potash. As soon as the prussiate appears to be decomposed and dissipated, plunge the article into cold water. When the process of case-hardening has been well conducted, the surface of the metal proves sufficiently hard to resist a file. The last two plans are a great improvement upon the common method. By the application of the prussiate, as in the last receipt, any part of a piece of iron may be case-hardened, without interfering with the rest.

3302. Improved Process of Hardening Steel. Articles manufactured of steel for the purposes of cutting, are, almost without an exception, taken from the forger to the hardener without undergoing any intermediate process; and such is the accustomed routine, that the mischief arising has escaped observation. The act of forging produces a strong scale or coating, which is spread over the whole of the blade; this scale or coating is unequal in substance, varying in proportion to the degree of heat communicated to the steel in forging; it is almost impenetrable to the action of water when immersed for the purpose of hardening. Hence it is that different degrees of hardness prevail in nearly every razor manufactured; this is evidently a positive defect; and so long as it continues to exist, great difference of temper must exist likewise. Instead, therefore, of hardening the blade from the anvil, let it be passed immediately from the hands of the forger to the grinder; a slight application of the stone will remove the whole of the scale or coating, and the razor will then be properly prepared to undergo the operation of hardening with advantage. It is plain that steel in this state heats in the fire with greater regularity, and that, when immersed, becomes equally hard from one extremity to the other. To this may be added, that, as the lowest possible heat at which steel becomes hard is indubitably the best, the mode here recommended will be found the only one by which the process of hardening can be effected with a less portion of fire than is, or can be, required in any other way. These observations are decisive, and will, in all probability, tend to establish in general use what cannot but be regarded as a very important improvement in the manufacturing of edge steel instruments.

3303. To Case-Harden Small Articles of Iron. Fuse together, in an iron vessel or crucible, 1 part prussiate of potash and 10 parts common salt, and allow the article to remain in the liquid 30 minutes, then put them in cold water and they will be case-hardened.

3304. To Clean a Shot Gun. Wrap clean tow around the cleaning rod; then take a bucket of tepid water—soap-suds if procurable—and run the rod up and down the barrel briskly until the water is quite black. Change the water until it runs quite clear through the nipple; pour clean tepid water down the barrel, and rub dry with fresh clean tow; run a little sweet oil on tow down the barrel for use. To clean the stock, rub it with linseed oil. If boiling hot water is used the barrel will dry sooner, and no fear need be apprehended of its injuring the temper of a fine gun. Some sportsmen use boiling vinegar, but we cannot recommend this method. The reason hot water does not injure the gun, is that boiling water is only 212° Fahr., and the gun was heated to 450° to give it its proper temper.

3305. Grease for Anointing Gun-Barrels on the Sea-Shore. It is said that an ointment made of corrosive sublimate and lard will prove an effectual protection against the rusting of gun-barrels on the sea-shore.

3306. To Protect Polished Steel from Rust. Nothing is equal to pure paraffine for preserving the polished surface of iron and steel from oxidation. The paraffine should be warmed, rubbed on, and then wiped off with a woolen rag. It will not change the color, whether bright or blue, and will protect the surface better than any varnish.

3307. To Protect Polished Metal from Rust. Take 10 pounds gutta-percha, 20 pounds mutton suet, 20 pounds beef suet, 2 gallons neats' foot oil, and 1 gallon rape oil. Melt together until thoroughly dissolved and mixed, and color with a small portion of rose pink; oil of thyme or other perfuming matter may be added. When cold the composition is to be rubbed on the surface of bright steel, iron, brass, or other metal, requiring protection from rust.

3308. To Remove Rust from Steel. Rust may be removed from steel by immersing the article in kerosene oil for a few days. The rust will become so much loosened that it may easily be rubbed off. By this simple method badly rusted knives and forks may be made to present a tolerable appearance, but for new goods there is no way to remove rust from metal but by getting below it, or renewing the surface. Where it is not deep-seated, emery paper will do, but if long standing the goods must be refinished.

3309. New Mode of Removing Rust. Plunge the article in a bath of 1 pint hydrochloric (muriatic) acid diluted with 1 quart water. Leave it there 24 hours; then take it out and rub well with a scrubbing-brush. The oxide will come off like dirt under the action of soap. Should any still remain, as is likely, in the corroded parts, return the metal to the bath for a few hours more, and repeat the scrubbing. The metal will present the appearance of dull lead. It must then be well washed in plain water several times, and thoroughly dried before a fire. Lastly, a little rubbing with oil and fine emery powder will restore the polish. Should oil or grease have mingled with the rust, it will be necessary to remove it by a hot solution of soda before submitting the metal to the acid. This last attacks the rust alone, without injuring the steel; but the washing in plain water is all-important, as, after the process, the metal will absorb oxygen from the atmosphere freely if any trace of the acid be allowed to remain.

Zinc. Zinc is a bluish white metal, having a specific gravity of 6.8 to 7.2; tough when cold, ductile and malleable at from 250° to 300° Fahr., brittle and easily pulverized at 500°; fuses at 773°, and sublimes unchanged at a white heat, in close vessels. It is scarcely affected by exposure to air and moisture; hence its general use in the arts for the manufacture of vessels of capacity, tubing, &c., that require lightness and durability. Acids, even diluted, attack zinc rapidly. It is also soluble in caustic alkalies. Heated to whiteness, 941° Fahr., in contact with the air, it burns with great brilliancy, and is converted into oxide, (flowers of zinc). It is very soluble in dilute sulphuric and muriatic acid, with the evolution of hydrogen gas. The salts of zinc are colorless.

Commercial zinc is never pure, and is obtained from the native sulphuret (zinc blende) or carbonate (calamine), by roasting those ores, and distilling them along with carbonaceous matter in a covered earthen crucible, having its bottom connected with an iron tube which terminates over a vessel of water situated beneath the furnace. The first portion that passes over contains cadmium and arsenic, and is indicated by what is technically called the *brown blaze;* but when the metallic vapor begins to burn with a bluish white flame, or the *blue blaze* commences, the volatilized metal is collected. Zinc may be alloyed with most of the metals. (*Cooley.*)

3311. Purification of Zinc. Granulate zinc by melting, and pouring it, while very hot, into a deep vessel filled with water. Place the granulated zinc in a Hessian crucible, in alternate layers, with one-fourth its weight of nitre, with an excess of nitre at the top. Cover the crucible, and secure the lid; then apply heat. When deflagration takes place, remove from the fire, separate the dross, and run the zinc into an ingot mould. It is quite free from arsenic.

3312. To Granulate Zinc. Granulated zinc is obtained by pouring the molten metal into a warm mortar and triturating vigorously, with an iron pestle, until it solidifies. (*See No.* 3311.)

3313. To Color Metals. Make a solution of 4 ounces hyposulphite of soda in $1\frac{1}{2}$ pints of water, and add a solution of 1 ounce acetate of lead in the same quantity of water. Articles to be colored are placed in the mixture, which is then gradually heated to a boiling point. The effect of this solution is to give iron the effect of blue steel, zinc becomes bronze, and copper or brass becomes successively yellowish red, scarlet, deep blue, bluish white, and finally white with a tinge of rose. This solution has no effect on lead or tin. By replacing the acetate of lead in the solution with sulphate of copper, brass becomes of a fine rosy tint, then green, and finally, of an iridescent brown color. Zinc does not color in this solution, it throws down a precipitate of brown sulphuret of copper; but if boiled in a solution containing both lead and copper, it becomes covered with a black crust, which may be improved by a thin coating of wax. (*See No.* 3188.)

Tin. This metal approaches silver in whiteness and lustre. When pure, it is very malleable; is harder than lead; melts at 442° Fahr., and volatilizes at a white heat. Its specific gravity is 7.29 to 7.31. This metal is decomposed by nitric, sulphuric, and muriatic acids; and may be combined and alloyed with most of the useful metals. Tin occurs in nature in the state of the oxide, and sometimes as sulphuret (tin pyrites.) In Cornwall, England, it is found under the name of tin-stone, associated with copper ore, in the slate or granite rocks; and as an alluvial deposit (stream tin) in the beds of rivers. A pure article of tin comes from Banca. The metal is obtained from the ore, first reduced to powder in stamping mills, washed to remove earthy matter, and then roasted to expel arsenic and sulphur; it is then deoxidized or reduced by smelting with about ⅛ its weight of powdered *culm* (a kind of coal found in Wales), and a little slacked lime; it is next refined by liquation (*see No.* 21), followed by a second smelting of the purer portion; it is then, while in a state of fusion, stirred with billets of green wood, allowed to settle, and cast into moulds. The product is termed refined or *block-tin*. Tin produces a peculiar crackling noise when bent; in this manner pure tin foil may be distinguished from the so-called tin foil in general use, which consists of lead with a tin surface only.

3315. Tests for the Purity of Tin. It is almost entirely dissolved by hydrochloric acid, yielding a colorless solution of muriate (chloride) of tin. If it contains arsenic, brownish-black flocks will be separated during the solution, and arseniuretted hydrogen evolved. The presence of other metals in tin may be detected by treating the muriate of tin solution with nitric acid, specific gravity 1.16, first in the cold, and afterwards with heat, until all the tin is precipitated in an insoluble peroxide; the decanted acid solution from pure tin leaves no residuum on evaporation. If there be a residuum, and dilution with water occasions a heavy white precipitate, the tin contained *bismuth*. If, after dilution, the addition of a solution of sulphate of ammonia or of soda produces a white precipitate, the tin contained *lead*. If red prussiate of potash gives a blue precipitate, it contained *iron*; and if the clear liquid leaves a residuum on evaporation, it contained *copper*.

3316. Grain Tin. This is made from block tin. The blocks are heated until they become brittle, and then allowed to fall from a considerable height, by which they are broken into small fragments, which constitute grain tin, or *tin in tears*.

3317. Tin Powder or Filings. Melt grain tin (*see No.* 3316) in an iron vessel, pour it in an earthen-ware mortar heated a little above its melting point, and triturate briskly as the metal cools; lastly, sift the product, and repeat the process with what remains in the sieve. Powdered tin is also prepared by filing and rasping.

3318. Powdered Tin. Take Cornish grain tin; melt it, and pour it into a wooden box, well rubbed on the inside with whiting or chalk; close the cover, and continue shaking it violently until the tin is reduced to powder; then wash it in clean water, and dry it immediately.

3319. To Make Feathered Tin. The object of feathering is to bring the tin into a state of minute subdivision, which permits it to be much more rapidly dissolved in acids. Procure an iron ladle having a capacity of about 12 fluid ounces, and a wooden or stoneware vessel containing 2 or 3 gallons of cold water. About 1 pound of pure bar tin, free from lead, is to be cut into pieces of about 2 inches in length, and melted in the ladle. When melted, pour the tin in a very small stream, from a height of about 3 feet, into the cold water. The ladle should be moved around in a small circle, when pouring, for if the whole of the melted tin strikes the water at one point, it will cool in lumps, and require remelting. The feathered tin is to be preserved in wooden boxes, the bottoms of which are perforated with small holes; or, what is better, kept in unglazed stoneware flower-pots. Solutions of tin containing iron or copper, or their salts, are unfit for dyeing bright reds. (*See Nos.* 107, *&c.*)

3320. Moire Metallique, or Crystallized Tin. A method of ornamenting the surface of tin plate by acids. The plates are washed with an alkaline solution, then in water, heated, and sponged or sprinkled with the acid solution. The appearance varies with the degree of heat and the nature and strength of the acids employed. The plates, after the application of the acids, are plunged into water, slightly acidulated, dried, and covered with white or colored varnishes. The following are some of the acid mixtures used: nitro-muriatic acid, in different degrees of dilution; sulphuric acid, with 5 parts of water, 1 part of sulphuric acid, 2 of muriatic acid, and 8 of water; a strong solution of nitric acid; 1 part nitric acid, 2 sulphuric, and 18 of water. A solution of potash is also used.

3321. Frosted Tin. A frosted appearance may be given to sheet tin by a wash of bichloride of tin.

3322. To Make a Tin Tree. Dissolve 3 drachms muriate (chloride) of tin in 1 pint distilled water, adding 10 or 15 drops nitric acid; and suspend a small rod of clean zinc in a phial containing the above solution.

Nickel.

A white, hard, malleable, magnetic metal, capable of receiving the lustre of silver. Its specific gravity, when hammered, is about 8.82. Nickel is very infusible. Muriatic and sulphuric acid act on it with difficulty unless mixed with nitric acid, but it is freely soluble in the latter. Nickel does not oxidize or tarnish at the ordinary temperature. It alloys well with copper, tin, zinc, etc. It is obtained as follows: Roast the powdered ore first by itself and then with charcoal powder, till all the arsenic is expelled, and a garlic odor ceases to be evolved; mix the residuum with 3 parts sulphur and 1 part potash; melt in a crucible with a gentle heat, cool, edulcorate with water, dissolve in sulphuric acid mixed with a little nitric acid, precipitate with carbonate of potash, wash, dry, mix the precipitate with powdered charcoal, and reduce it by heat. For chemical purposes pure nickel is best obtained by moderately heating its oxalate in a covered crucible, lined with charcoal. The salts of nickel in the anhydrous state are for the most part yellow; when hydrated, green, and furnishing pale green solutions. Nickel is found present in meteoric iron, and is strongly magnetic, but loses this property when heated to 350° Fahr. It is chiefly employed in the manufacture of German silver. Sulphate of nickel is used medicinally, with soothing and soporific effects.

Mercury or Quicksilver.

This is a heavy liquid metal, possessing a nearly silver-white color, and a brilliant metallic lustre. The principal sources of this metal at the present time are the mines of Idria in Carniola, and Almaden in Spain, where it exists under the form of cinnabar, from which the pure metal is obtained by distilling that ore with lime or iron filings in iron retorts, by which the sulphur it contains is seized and retained, while the mercury rises in the state of vapor, and is condensed in suitable receivers. Its specific gravity, when pure, is 13.5; it solidifies at —39° (39° below zero) Fahr., and when solid is ductile, malleable, and tenacious; boils at 662° Fahr., but volatilizes slowly at the ordinary temperature of the atmosphere, and when mixed with water at from 140° to 160°, it is volatilized in considerable quantities. It unites with oxygen, forming two oxides; and with chlorine, forming calomel and corrosive sublimate; with the metals it forms amalgams, combining, however, with difficulty with iron, nickel, platinum, and some other less important metals. Its oxides form salts with the acids. The only acids that act on metallic mercury are the sulphuric and nitric; but for this purpose the former must be heated.

3325. Test for the Purity of Mercury. Metallic mercury may be known by its volatility; and when in a finely divided or pulverulent state, by the microscope, or by staining a piece of copper white when rubbed on it, or when heated beneath it. It is totally dissipated by heat, and dissolved by diluted nitric acid, but is insoluble in boiling muriatic acid. The acid poured off, and allowed to cool, is neither colored, nor yields a precipitate with sulphuretted hydrogen. A globule moved about on a sheet of paper yields no trail; pure sulphuric acid agitated with it (in the cold) evaporates when heated, without leaving any residuum.

3326. To Purify Mercury. Mercury, as imported, is usually very pure. It may be prepared for medical purposes by putting 6 parts into a retort and distilling off 4 parts. The whole of the mercury may, however, be safely drawn over. The product is to be agitated and boiled with 2 fluid drachms hydrochloric acid and 1 fluid ounce water for each pound of the metal; then washed with pure water, and dried by heat. A strong earthenware or iron retort, with a low neck or tube dipping into a basin of water, may be used for this purpose.

3327. To Purify Mercury. One of the quickest and best means of purifying mercury is to agitate it with a concentrated solution of nitrate of mercury, at a heat of 104° Fahr., then wash it with distilled water, and dry by passing several times through clean, dry chamois leather.

3328. To Purify Mercury. Distill equal parts of mercury and iron filings in an iron retort, into a vessel containing water.

3329. To Purify Mercury. The following simple method of purifying quicksilver is by Dr. Miller: Put the quicksilver into a bottle capable of containing 4 times its quantity, add a little powdered loaf sugar, and stopper the bottle; shake it vigorously for a few minutes, then open the bottle and blow fresh air into it with a pair of bellows. Repeat this 3 or 4 times, and filter the mixture through a cone of smooth writing paper having its apex pierced with a fine pin. The sugar is left behind in the filter with the oxides of any other metals present, and a small quantity of mercury in a state of minute division.

Aluminum.

This is the metallic base of alumina, which is the plastic principle of certain kinds of clay. The color of aluminum is white, inclining to blue; it is very malleable, and ductile. Its specific gravity is only about 2.60; its melting point not less than 1000° Fahr. It is the most sonorous of all metals. It is thus obtained:—Make a thick paste of alumina, powdered charcoal, sugar, and oil, and heat it in a covered crucible until all the organic matter is destroyed; then transfer the product to a porcelain tube, and connect the one end with another tube containing dried chloride of calcium, and the other end with a small tubulated receiver. Then expose the porcelain tube to the heat of a small oblong furnace, and, having connected the chloride of calcium tube with a vessel disengaging chlorine, pass the gas through the apparatus, at the same time raising the heat of the tube to redness. In 1 or 2 hours, or as soon as the tube becomes choked, the whole must be allowed to cool, and taken to pieces, and the sesquichloride of aluminum thus formed collected. Then place 9 or 10 pieces of potassium, of about the size of peas, in a platina crucible, and upon them an equal number of similar pieces of the sesquichloride of alumina, formed as above; the cover is now to be put on and secured in its place with a wire, and the heat of a spirit lamp cautiously applied, until the spontaneous incandescence of the matter ceases. When cold, throw the crucible into a large vessel of cold water, agitate and collect the gray powder deposited, and again wash it well and dry it. This gray powder consists of small metallic scales, resembling platina. It is not acted on by cold water, but is dissolved by the alkalies and some of the acids. Heated to redness, it catches fire and burns with great rapidity in the air, and in oxygen gas, with intense brilliancy. The powder, blown upon the flame of a candle, displays an immense number of inflamed points of great splendor.

3331. To Polish Aluminum. The substances generally employed for polishing aluminum are of no utility. Mouray recommends the use of an emulsion of equal parts of rum and olive oil, made by shaking these liquids together in a bottle. When the burnishing stone is used, the peculiar black streaks first appearing should not cause vexation, since they do not injure the metal in the least, and may be removed with a woolen rag. The objects in question may also be brightened in potash lye, in which case, however, care must be taken not to make use of too strong a lye. For cleaning purposes, benzole has been found best. Objects of aluminum can be electro-plated without the least difficulty, and Mouray succeeded in imparting to them a bright, white lustre in passing them successively through a weak bath of hydrofluoric acid and aqua fortis. The effect thus obtained is said to be really surprising.

3332. To Frost Aluminum. The metal is plunged into a solution of caustic potash. The surface, becoming frosted, does not tarnish on exposure to the air.

Platinum

Platinum—also called platina—is the heaviest substance but one (*see No.* 47) known, having a specific gravity of fully 21, which may be raised to about 21.5 by hammering. It is whiter than iron, harder than silver, infusible in the hottest furnace, and melts only before the compound blow-pipe at a heat of about 3080° Fahr. On this account it is valuable for making capsules &c., intended to resist strong heat. Platinum undergoes no change by exposure to air and moisture, or the strongest heat of a smith's forge, and is not attacked by any of the pure acids, but is dissolved by chlorine and nitro-muriatic acid (aqua regia), though with more difficulty than gold. Spongy and powdered platinum possess the remarkable property of causing the union of oxygen and hydrogen gases. It is chiefly imported from South America, but is also found in the Ural Mountains of Russia, in Ceylon, and a few other places. Platinum, when alloyed with silver, is soluble in nitric acid; the pure metal is dissolved by aqua regia, and is more or less attacked by caustic alkali, nitre, phosphorus, &c., with heat. Platinum is precipitated from its solutions by deoxidizing substances under the form of a black powder, which has the power of absorbing oxygen, and again imparting it to combustible substances, and thus causing their oxidation. In this way alcohol and pyroxilic spirit may be converted into acetic and formic acids, &c. (*See No.* 1741, *also Acetic Acid.*) (*Cooley.*)

3334. To Purify Platinum. The native alloy (crude platinum) is acted upon, as far as possible, with nitro-muriatic acid, containing an excess of muriatic acid, and slightly diluted with water. The solution is precipitated by the addition of sal-ammoniac, which throws down nearly the whole of the platinum in the state of an *ammonio-chloride*, which is washed with a little cold water, dried, and heated to redness; the product is spongy metallic platinum. This is made into a thin uniform paste with water, pressed in a brass mould, to squeeze out the water and render the mass sufficiently solid to bear handling. It is then dried, carefully heated to whiteness, and hammered or pressed in the heated state; after this treatment it may be rolled into plates or worked into any desired shape. (*Cooley*).

3335. Platinated Asbestos. Dip asbestos in a solution of chloride of platinum, and heat it to redness. It causes the inflammation of hydrogen in the same manner as sponge platinum.

3336. Spongy Platinum. Dissolve separately crude bichloride of platinum, and hydrochlorate of ammonia in proof spirit; add the one solution to the other as long as a precipitate falls; this is collected, and, while still moist, formed into little balls or pieces, which are then dried, and gradually heated to redness.

3337. Spongy Platinum. Dissolve platinum, by the aid of heat, in a mixture of three parts nitric and 5 parts muriatic acid, avoiding great excess of acid. To this solution add a strong solution of muriate of ammonia; collect the resulting precipitate on a filter, and, when nearly dry, form it into a mass of the shape desired for the sponge. Heat this to whiteness on charcoal, with a blow-pipe or otherwise, and the platinum remains in the spongy state. Its characteristic properties may be restored, when lost, by simply heating it to redness.

3338. Platinum-Black. Platina Mohr. This is platinum in a finely divided state, and is obtained thus:—Add to a solution of bichloride of platinum, an excess of carbonate of soda, and a quantity of sugar. Boil until the precipitate which forms becomes, after a little while, perfectly black, and the supernatant liquid colorless; filter the powder, wash, and dry it by a gentle heat. Another method is by melting platina ore with twice its weight of zinc, powdering, digesting first in dilute sulphuric acid, and next in dilute nitric acid, to remove the zinc, assisting the action of the menstruum by heat; it is then digested in potash lye, and lastly in pure water, after which it is carefully dried. Platinum-black possesses the property of condensing gases, more especially oxygen, into its pores, and afterwards yielding it to various oxidizable substances. If some of it be mixed with alcohol into a paste, and spread on a watch glass, pure acetic acid is given off, and affords a ready means of diffusing the odor of vinegar in an apartment. (*See No.* 1741.)

Antimony

Antimony. This is a bluish-white, lustrous, semi-crystalline, extremely brittle metal, of about 6.7 specific gravity; imparts brittleness to alloys; inflammable at high temperature; melts just under redness, 810° Fahr., fumes, boils, and volatilizes at a white heat, and when suddenly exposed to the air, inflames and is converted into teroxide of antimony, which is deposited in beautiful crystals. Antimony dissolves in hot hydrochloric acid, forming terchloride of antimony; nitric acid converts it into antimonic acid. This metal is obtained principally from France and Germany. Gold, when exposed to the vapors of antimony, loses its ductility and malleability, and becomes as brittle as antimony itself.

3340. Tests for Antimony. An acid solution of antimony gives, in combination with sulphuretted hydrogen, an orange-red precipitate, sparingly soluble in ammonia, but readily soluble in pure potassa and alkaline sulphurets. Hydrosulphuret of ammonia throws down from the acid solution an orange-red precipitate, readily soluble in excess of the precipitant, if the latter contain sulphur in excess; and the liquor containing the re-dissolved precipitate gives a yellow or orange-yellow precipitate on the addition of an acid. Ammonia, and potassa, and their carbonates (excepting in solutions of tartar emetic) give a bulky white precipitate; that from ammonia being insoluble in excess of the precipitant; that from potassa readily so; while those from the carbonate are only soluble on the application of heat.

3341. To Estimate the Purity of Antimony. Treat pulverized antimony with nitric acid; this oxidizes the antimony, and leaves it in an insoluble state, whilst it dissolves the other metals. Collect the oxide on a filter, wash, dry, ignite, and weigh it. This weight, multiplied by .843, gives the weight of pure metal in the sample examined. If this has been previously weighed, the percentage of pure metal is easily arrived at.

3342. To Obtain Metallic Antimony. Mix together 16 parts sulphuret of antimony and 6 parts cream of tartar, both in powder; put the mixture, in small quantities at a time, into a vessel heated to redness; when reaction ceases, fuse the mass, and, after 15 minutes, pour it out and separate the metal from the slag. The product is nearly pure.

Or: Equal parts of protoxide of antimony and bitartrate of potassa (cream of tartar); mix and fuse as above, and pour the metal into small conical moulds.

Or: 8 parts sulphuret of antimony, 6 parts cream of tartar, and 3 parts nitre. Treated as above.

Or: 2 parts sulphuret of antimony and 1 part iron filings; calcine at a strong heat in a covered crucible.

3343. To Obtain Commercial Antimony. Fuse together 100 parts sulphuret of antimony, 40 parts metallic iron, and 10 parts dry crude sulphate of soda. This produces from 60 to 65 parts of antimony, besides the scoriæ or ash, which is also valuable.

Bismuth

Bismuth. This metal is principally prepared in Germany, and, as imported, generally contains both arsenic and copper. It is a crystalline metal, very brittle, of a reddish white color; melts at about 500° Fahr., volatilizes at a strong heat, and the fumes form crystalline scales (flowers of bismuth). It burns when strongly heated in the air, and has a specific gravity of about 9.8. The addition of bismuth to other metals lowers their melting point in an extraordinary manner, making it a useful ingredient in the composition of type-metal and solders. (*See No.* 3499, *etc.*)

3345. To Purify Bismuth. Dissolve crude bismuth in nitric acid, and concentrate the solution by evaporation. Then pour the clear solution into a large bulk of distilled water, and a white powder (sub-nitrate of bismuth) will be precipitated. Collect the precipitate and digest it for a time in a little caustic potash, to dissolve away any arsenious acids that may be present; next wash and dry the sub-nitrate; heat it with about $\frac{1}{10}$ its weight of charcoal in an earthen crucible, and the pure bismuth will be found at the bottom of the crucible. (*Makins.*)

3346. To Separate Bismuth from Lead. Dissolve the mixed metal in nitric acid; add caustic potash in excess, and the oxides of bismuth and lead will be precipitated, but the lead oxide will be at once re-dissolved by the alkali. The oxide of bismuth can then be separated by filtration, washed, and ignited. (*Makins.*)

Alloys. Combinations of the metals with each other obtained by fusion. When mercury is one of the component metals, the compound is termed an amalgam. (*See No.* 3532.) Most of the metals unite with each other by fusion or amalgamation, and acquire new properties. Thus: copper alloyed with zinc, becomes brass, and possesses a different density, hardness, and color to either of its constituents. No general rules for the manufacture of alloys applicable to each can be given; but it may be remarked that, in uniting metals differing greatly in their melting points, the least fusible should be melted first, and the others added, one at a time, in their order of fusibility, the most fusible metal being the last to be added; also that, before the addition of each succeeding metal, the temperature of the already fused mass should be reduced to the lowest point at which it will remain fluid, or as near as possible to the fusing point of the metal to be next introduced, so that it may not evaporate or be oxidized, and thus cause the compound to be imperfect. This is a general rule, to be applied in most cases; but there are exceptions. For instance: gold will easily dissolve in melted tin; and platinum in many metals. If platinum were first melted, and zinc, for instance, added, the temperature necessary to obtain the fusion of platinum would be sufficient to volatilize the zinc. The mixture is usually effected under a flux, or some material that will prevent evaporation and exposure to the atmosphere. Thus: in melting lead and tin together, in forming solder, resin or tallow is thrown upon the surface; in tinning copper, the surface is rubbed with sal-ammoniac; and in combining some metals, powdered charcoal is used for the same purpose. (*See No.* 3470.) As we have already said, most of the alloys are prepared by simply fusing the metals together; but if there be a considerable difference in their specific gravities, the heavier very generally subsides, and the lower part of the mass thus differs in composition from the upper. This may be in a great measure prevented by agitating the alloy til' it solidifies, but this is not always convenient. Thus, in stereotype plates, which are cast vertically, the upper side usually contains more antimony than the other. As a general rule, the substances (elements) of nature unite together in fixed and definite atomic proportions, thereby forming new compounds. Metals unite with non-metallic bodies, and obey the same general law; but metals, when united with metals, appear to form an exception, though much doubt exists on the subject. They seem to mix in any proportion, and are thereby modified, possessing thereafter properties which fit them for many purposes in commerce and art. These compounds, being considered at present non-chemical bodies, are classed together under the French term of alloys. Alloys are generally more fusible than the least fusible of the component metals; but are often harder and more brittle than the hardest and most brittle of the component metals. With some exceptions, the ductility and tenacity of an alloy is less than that of its metals.

3348. Table of the Principal Alloys of Copper. This table of the alloys of copper is from Dr. Ure. The bronze for statues is the composition used by Keller Brothers, the celebrated brass founders.

	Copper.	Zinc.	Tin.	Nickel.	Antimony	Lead.
Antique bronze sword	87.000		13.000			
" springs	97.000		3.000			
Bronze for statues	91.400	5.530	1.700			1.370
" for medals	90.000		10.000			
" for cannon	90.000		10.000			
" for cymbals	78.000		22.000			
" for gilding	82.257	17.481	0.238			0.024
" "	80.000	16.500	2.500			1.000
Speculum metal	66.000		34.000			
Brass for sheet	84.700	15.300				
Gilding metal	73.730	26.270				
Prince's metal	75.000	25.000				
" "	50.000	50.000				
Dutch metal	84.700	15.300				
English wire	70.290	29.260	0.170			0.280
Mosaic gold	66.000	34.000				
Gun metal for bearings, stocks, &c.	90.300	9.670	0.030			
Muntz's metal	60.000	40.000				
Good yellow brass	66.000	34.000				
Babbitt's metal for bushing	8.300		83.400		8.300	
Bell metal for large bells	80.000		20.000			
Britannia metal	1.000	2.000	81.000		16.000	
Nickel silver, English	60.000	17.800		22.200		
" " Parisian	50.000	13.600		19.300		
German silver	50.000	25.000		25.000		
Pinchbeck	80.200	20.000				

3349. Properties of Metals. The metals form part of the elements of nature, are undecompounded bodies, and distinguished from the other elements by their lustre, weight, &c.

3350. Table Showing, in their Order, the Comparative Properties of Metals.

Order of Malleability.	Order of Ductility.	Order of Brittleness.
Gold,	Gold,	Antimony,
Silver,	Silver,	Arsenic,
Copper,	Platinum,	Bismuth,
Tin,	Iron,	Chromium,
Cadmium,	Copper,	Cobalt,
Platinum,	Zinc,	Manganese,
Lead,	Tin,	Molybdenum,
Zinc,	Lead,	Tellurium,
Iron,	Nickel,	Titanium.
Nickel,	Palladium,	Tungsten,
Palladium,	Cadmium,	Uranium,
Potassium,		Rhodium.

Order of Tenacity.		Order of Heat Conducting Power.	Order of Electrical Conducting Power.
Iron,	1,000	Gold,	Copper,
Copper,	550	Platinum,	Gold,
Platinum,	494	Silver,	Silver,
Silver,	349	Copper,	Zinc,
Gold,	273	Iron,	Platinum,
Zinc,	199	Zinc,	Iron,
Tin,	63	Tin,	Tin,
Lead,	50	Lead,	Lead,
			Mercury,
			Potassium.

3351. Lustre is so characteristic as to have formed the common expression "metallic lustre."

3352. Weight is also a rough distinguishing characteristic.

3353. Fusibility is a property common to all metals. Before some metals are rendered fluid by heat, they become pasty; such is an indication of malleability. The following table gives the degrees (Fahr.) of heat at which metals fuse:

Tin	442°
Bismuth	497°
Lead	612°
Zinc	773°
Antimony	810°
Silver	1,873°
Copper	1,996°
Gold	2,016°
Iron (Cast)	2,786°
Nickel	2,800° (about)
Manganese	3,000° (about)

3354. Malleability, or the property of being beaten out into thin plates without cracking or breaking, is common to several metals.

3355. Ductility is also a property found in some metals. It is allied to malleability, and often confounded with it. It is the property of being drawn into wire.

3356. Tenacity, or the resistance of being pulled asunder by the force of tension, varies exceedingly in metals.

3357. Brittleness, resulting from hardness, is a property also met with; and where the brittleness is not extreme, hardness is in favor where subjected to compression.

3358. How to Make Brass. This useful alloy of copper and zinc is now generally made by plunging the copper in slips into the zinc melted in the usual manner. The former metal rapidly combines with the fluid mass, and the addition is continued until an alloy is formed somewhat difficult of fusion, when the remainder of the copper is at once added. The brass thus formed is broken into pieces and remelted under charcoal, and a proper addition of either zinc or copper made to bring it up to the color and quality desired. Small quantities of brass may be made by melting the copper and zinc separately, pouring them together and stirring vigorously. (*See Copper Flux, No.* 3470.) It is then poured into moulds of granite. Before being submitted to the rolling press for reduction to thin plates, it has to undergo the operation of annealing. In the receipts which follow, it will be seen that the larger the proportion of copper, the darker the color, the greater the density, and, to a certain extent, the toughness, of the alloy. Zinc lessens the weight and color. Tin gives it hardness and grain, and lead toughens it and renders it fitter for working. An application of these principles will serve as a guide for the metals and proportions to be used to produce a brass of any description required.

3359. Fine Light Yellow Brass. Melt together 2 parts copper and 1 part zinc.

3360. Bright Yellow Malleable Brass. Melt together 7 parts copper and 3 parts zinc.

3361. Deep Yellow Malleable Brass. Melt together 4 parts copper and 1 part zinc.

3362. Brass Malleable whilst Hot. Melt together 3 parts copper and 2 parts zinc.

3363. Red Brass. Melt together 5 parts copper and 1 part zinc. As much as 10 parts of copper to 1 part zinc may be used, the color being a deeper red for every additional part of copper employed.

3364. Brass for Buttons. Copper, 8 parts, and zinc 5 parts. This is the Birmingham *platin*.

3365. Pale Brass for Buttons, &c. Melt together 16 parts fine light yellow brass (*see No.* 3359), 2 parts zinc, and 1 part tin.

3366. Common Pale Brass. Melt together 25 parts copper, 20 parts zinc, 3 parts lead, and 2 parts tin.

3367. Fine Pale Brass for Castings. Melt together 15 parts copper, 9 parts zinc, and 4 parts tin. This is rather brittle.

3368. Dark Brass for Castings. Melt together 90 parts copper, 7 parts zinc, 2 parts tin, and 1 part lead. The color will be still deeper by using 2 parts less of zinc, and 1 part more each of copper and tin.

3369. Pale Brass for Gilding. Melt together copper, 64 parts; 32 parts zinc, 3 parts lead, and 1 part tin.

3370. Red Brass for Gilding. Melt together 82 parts copper, 18 parts zinc, 3 parts tin, and 1 part lead.

3371. Brass for Solder. Melt together 12 parts fine yellow brass (*see No.* 3359), 6 parts zinc, and 1 part tin. Used for ordinary brazing.

3372. Pale Brass for Turning. Melt together 98 parts fine brass (*see No.* 3359), and 2 parts lead.

3373. Red Brass for Turning. Melt together 65 parts copper, 33 parts zinc, 2 parts lead.

3374. Red Brass for Wire. Melt together 72 parts copper and 28 parts zinc, properly annealed.

3375. Pale Brass for Wire. Melt together 64 parts copper, 34 parts zinc, and 2 parts lead.

3376. To Make Brass which Expands by Heat Equally with Iron. It is difficult to make a permanent joint between brass and iron, on account of their unequal expansion by heat. In a recent issue of the journal of "Applied Chemistry," a new alloy is given, for which the inventor claims an expansion by heat so nearly similar to that of iron, as to allow of a union between them, which, for all practical purposes, is permanent. This consists of a mixture of 79 parts copper, 15 parts zinc, and 6 parts tin.

3377. To Harden Brass. Brass is tempered or hardened by rolling or hammering; consequently, if any object is to be made of tempered brass, the hardening must be done before working it into the required shape.

3378. To Soften Brass. Heat it to a cherry red, and plunge it into water.

3379. To Cover Brass with Beautiful Lustre Colors. Dissolve 1 ounce cream of tartar in 1 quart boiling water; then add ½ ounce protochloride of tin dissolved in 4 ounces cold water. Next heat the whole to boiling, and decant the clear solution from a trifling precipitate, and pour, under continual stirring, into a solution of 3 ounces hyposulphate of soda in ½ pint water, then heat again to boiling, and filter from the separated sulphur. This solution produces on brass the various lustre colors, depending on the length of time during which the articles are allowed to remain in it. The colors at first will be light to dark gold yellow, passing through all the tints of red to an iridescent brown. A similar series of colors is produced by sulphide of copper and lead, which, however, are not remarkable for their stability; whether this defect will be obviated by the use of the tin solution, experience and time alone can show.

3380. To Put a Black Finish on Brass Instruments. Make a strong solution of nitrate of silver in one dish, and of nitrate of copper in another. Mix the two together, and plunge the brass in it. Now heat the brass evenly till the required degree of dead blackness is obtained. This is the method of producing the beautiful dead black so much admired in optical instruments, and which was so long kept a secret by the French.

3381. To Frost Watch Movements. Mix together 1 ounce each muriatic acid, nitric acid, and common salt; immerse the article, as far as it is to be frosted, in the mixture for a short time; then immerse it, so as just to cover it, in sour beer, and scour it under the beer with a brush made of fine brass wire (a scratch brush); wash it in water, and afterwards in alcohol. The surface is then ready to gild or silver-plate if desired.

3382. To Color Brass. Although no alloy presents a more agreeable appearance to the eye than brass when it is in a high state of polish, yet the facility with which it tarnishes has rendered it necessary to color or bronze it, especially in those instances where its use exposes it to the liability of being frequently handled. The following receipts are from a reliable German source, and are said to possess a high degree of permanence. (*See Nos.* 3771, *&c.*)

3383. To Give Brass an Orange Tint. An orange tint, inclining to gold, is produced by first polishing the brass and then plunging it for a few seconds into a neutral solution of crystallized acetate of copper, care being taken that the solution is completely destitute of all free acid, and possesses a warm temperature.

3384. To Color Brass Grey-Green. Dipped into a bath of copper, the brass being first polished, as in last receipt, the resulting tint is a grayish green.

3385. To Color Brass Violet. A beautiful violet is obtained by immersing the polished brass for a single instant in a solution of chloride of antimony, and rubbing it with a stick covered with cotton. The temperature of the brass at the time the operation is in progress has a great influence upon the beauty and delicacy of the tint; in this instance it should be heated to a degree so as just to be tolerable to the touch.

3386. To Give Brass a Moiré Appearance. A moiré appearance, vastly superior to that usually seen, is produced by boiling the object in a solution of sulphate of copper. According to the proportions observed between the zinc and the copper in the composition of the brass, so will the tints obtained vary. In many instances it requires the employment of a slight degree of friction, with a resinous or waxy varnish, to bring out the wavy appearance characteristic of moiré, which is also singularly enhanced by dropping a few iron nails into the bath.

3387. Black Lacquer for Brass. There are two methods of procuring a black lacquer upon the surface of brass. The one usually employed for optical and scientific instruments consists in first polishing the object with Tripoli, then washing it with a mixture composed of 1 part nitrate of tin and 2 parts chloride of gold, and, after allowing this wash to remain for nearly a quarter of an hour, wiping it off with a linen cloth. An excess of acid increases the intensity of the tint.

By another method copper turnings are dissolved in nitric acid until the acid is saturated; the objects are cleaned, immersed in the solution, and subsequently heated moderately over a charcoal fire. This process must be repeated in order to produce a black color, as the first trial only gives a deep green, and the finishing touch is to polish with olive oil.

3388. To Give Brass an English Look. Much pains are taken to give brass objects an English look. For this purpose they are first heated to redness, and then dipped in a weak solution of sulphuric acid. Afterwards they are immersed in dilute nitric acid, thoroughly washed in water, and dried in sawdust. To effect a uniformity in the color they are plunged into a bath consisting of 2 parts nitric acid and 1 part rain water, where they are suffered to remain for several minutes. Should the color not be free from spots and patches, the operation must be repeated until the desired effect is produced.

3389. To Clean Brass. Brass and copper are best cleaned with sweet oil and Tripoli, powdered bath-brick, rotten stone, or red brick-dust, rubbed on with flannel and polished with leather. Vitriol and muriatic acid make brass and copper very bright, but they very soon tarnish, and consequently require more frequent cleaning. A strong lye of roche-alum and water will also improve brass. A solution of oxalic acid rubbed over tarnished brass with a cotton rag, soon removes the tarnish, rendering the metal bright. The acid must be washed off with water, and the brass rubbed with whitening in powder and soft leather. When acids are employed for removing the oxide from brass, the metal must be thoroughly washed afterwards, or it will tarnish in a few minutes after being exposed to the air.

3390. To Give a Golden Color to Brass. A mixture of muriatic acid and alum dissolved in water imparts a golden color to brass articles that are steeped in it for a few seconds.

3391. Paste to Clean Brass. Soft soap, 2 ounces; rotten-stone, 4 ounces; beat them to a paste. Or: Rotten stone made into a paste with sweet oil. Or: Rotten-stone, 4 ounces; oxalic acid, 1 ounce; sweet oil, 1½ ounces; turpentine enough to make a paste. The first and last are best applied with a little water. The second, with a little spirits of turpentine, or sweet oil. Both require friction with soft leather.

3392. To Clean Brass Inlaid Work. Mix Tripoli and linseed oil, and dip into it a rubber made of a piece of an old hat, with which polish the work and rub off with clean soft leather. If the wood be ebony or rosewood, polish it with a little finely powdered elder ashes; or make a paste of rotten-stone, a little starch, sweet oil, and oxalic acid, mixed with water. The ornaments of a French clock are, however, best cleaned with bread-crumb, carefully rubbed, so as not to spoil the wood-work. Ormolu candlesticks, lamps, and branches, may be cleaned with soap and water. They will bear more cleaning than lacquered articles, which are spoiled by frequent rubbing, or by acids or strong alkalies.

3393. Solutions to Clean Brass. Finely powdered sal-ammoniac; water to moisten. Or: Roche alum, 1 part; water, 16 parts. Mix. The articles to be cleaned must be made warm, then rubbed with either of the above mixtures and finished with fine Tripoli. This process will give them the brilliancy of gold.

3394. Solution for Cleaning Brass Chains. Mix together 1 ounce sulphuric acid, $\frac{3}{4}$ ounce nitric acid, $\frac{1}{2}$ drachm saltpetre, and 1 ounce rain water, and allow the solution to repose a few hours. Pass the article to be cleaned rapidly through the solution, and immediately wash it thoroughly with rain water. Dry in sawdust. This process will make old and discolored chains look as good as new.

3395. To Clean Very Dirty Brass. Rub some bichromate of potassa fine, pour over it about twice the bulk of sulphuric acid, and mix this with an equal quantity of water. Wash immediately in plenty of water, wipe it, and rub perfectly dry, and polish with powdered rotten-stone. By this method the dirtiest brass may be made immediately bright.

3396. To Give Brass Ornaments a Fine Color. Brass ornaments, when not gilt or lacquered, may be cleansed, and a fine color given to them, by two simple processes. The first is to beat sal-ammoniac into a fine powder, then to moisten it with soft water, rubbing it on the ornaments, which must be afterwards rubbed dry with bran and whiting. The second is to wash the brass work with roche alum boiled to a strong lye, in the proportion of 1 ounce to 1 pint; when dry, it must be rubbed with fine Tripoli. Either of these processes will give to brass the brilliancy of gold.

3397. Counterfeit Gold. Fuse together 8 parts platinum, 5 parts pure copper, 2 parts pure zinc, 4 parts tin, and 3 parts pure lead, using saltpetre, sal-ammoniac, and powdered charcoal as fluxes. This compound metal strongly resembles gold in appearance, and resists many of the tests used for gold.

3398. Hard Gold. A mixture of 7 parts gold and 1 part copper appears to afford the maximum of hardness.

3399. Coin Gold. Melt together with saltpetre and sal-ammoniac, 22 grains pure gold with 2 grains of pure copper. The later American coin is alloyed with 2 grains of a mixture of 1 part silver and 2 parts copper. The copper used for alloying gold must be *pure*, otherwise the mixture will be brittle.

3400. To Make Eighteen Carat Gold. Pure gold, 18 parts, is alloyed with 4 parts pure copper and 2 parts silver. Or: $19\frac{3}{4}$ parts coin gold, 3 parts copper, and $1\frac{1}{4}$ parts silver.

3401. To Make Sixteen Carat Gold. Sixteen parts pure gold are mixed with $5\frac{1}{2}$ parts copper, and $2\frac{1}{2}$ parts silver. Or: 17 parts coin gold, 5 parts copper, and 2 parts silver.

3402. To Make Twelve Carat Gold. Coin gold, 75 parts; further alloyed with 40 parts copper, and 22 parts silver, make a combination of good appearance, which stands acid tests well.

3403. To Make Four Carat Gold. A good useful metal for cheap rings, &c., which will not blacken the finger, is made by mixing 4 parts gold with 2 parts silver, and 18 parts copper.

3404. To Make Green Gold. Pure gold, 19 parts, and 5 parts pure silver, combine to form an alloy of a beautiful green shade, very effective for foliated designs in jewelry.

3405. Pivots for Artificial Teeth. An alloy of platinum and silver is used for this purpose.

3406. Chandet's Springs for Artificial Teeth. Equal parts of copper, silver, and palladium.

3407. Hard Silver. An alloy of 5 parts silver and 1 part copper forms the hardest alloy of these metals.

3408. French Coin Silver. This consists of 9 parts silver and 1 part copper.

3409. German Silver. This is a well-known alloy, the finer varieties of which nearly equal silver in whiteness and susceptibility of receiving a high polish, while they surpass it in hardness and durability. The mixture of the metals is effected in the same way as is given for making alloys. (*See No.* 3347.) The receipts here given are from the highest authorities, or are the results of actual analysis of the finest commercial samples.

3410. German Silver for Rolling. Nickel and zinc, each 1 part; copper, 2 parts. Very fine. Or: nickel, 25 parts; zinc, 20 parts; copper, 60 parts. Used for rolling.

3411. German Silver for Castings. Nickel and zinc, each 20 parts; copper, 60 parts; lead, 3 parts. For castings. Or, to either of the above add 2 to 3 per cent. of white sheet iron.

3412. Genuine German Silver. Copper, $40\frac{2}{5}$ parts; nickel, $31\frac{3}{5}$ parts; zinc, $25\frac{2}{5}$ parts; iron, $2\frac{3}{5}$ parts. This resembles the genuine German silver made from the ore of Hildburghausen, as well as Pakfong, as analyzed by Dr. Fyfe, and is equal to the best Chinese sample.

3413. Pelouze's German Silver. Equal parts of copper and nickel. Said to be superior to any of the alloys containing zinc. 2 parts of copper to 1 part of nickel make the alloy more malleable, though not so white.

3414. Chinese White Copper. This consists of 30 parts copper, 36 parts nickel, and 34 parts zinc.

3415. Pakfong, or White Copper from China. This is composed of 41 parts copper, 32 parts nickel, $2\frac{3}{5}$ parts iron, and $24\frac{2}{5}$ parts zinc. The Chinese Pakfong is said to be prepared from native ore. It is silvery white, takes a high polish, very sonorous, malleable both cold and at a dull red heat, and may be rolled into leaves or drawn into wire.

3416. White Spoon Metal. This is the alloy sold *as German plate.* Melt together 55 parts copper, 24 parts nickel, 16 parts zinc, 3 parts tin, and 2 parts iron. This is a useful alloy.

3417. Britannia Metal. Plate brass, 4 ounces; tin, 4 ounces; when fused add 4 ounces each of bismuth and antimony. This composition is added at discretion to melted tin.

3418. To Clean Britannia Ware. Britannia ware should be first washed with a woolen cloth and sweet oil, then washed in water and suds, and rubbed with soft leather and whiting. Thus treated, it will retain its beauty to the last. Britannia ware may also be cleaned in the same way as copper, in No. 3252.

3419. Type Metal. Lead, 3 parts; antimony, 1 part; melted together. Small types are usually made of a harder composition than large ones. A good stereotype metal is said to be made of lead, 9 parts; antimony, 2 parts; bismuth, 1 part. This alloy expands as it cools, and consequently brings out a fine impression.

3420. Bismuth and Lead. Lead, 2 parts to bismuth, 1 part, gives an alloy which dilates powerfully at the time of cooling. This property makes it extremely suitable to all castings in which the greatest sharpness and finish are desirable.

3421. Tin and Zinc. Tin and zinc, of each 1 part, is almost as tenacious as brass, and melts at 900° Fahrenheit.

3422. Pewter. Tin, 100 parts; antimony, 8 parts; copper, 4 parts; and bismuth, 1 part, constitute the compound commonly called pewter.

3423. Alloys of Steel. Steel is successfully alloyed with other metals, improving its qualities for some purposes. $\frac{1}{500}$ part of silver adds immensely to the hardness of steel, and yet increases its tenacity. $\frac{1}{100}$ part of platinum, though not forming so hard an alloy as the silver and steel, gives a very great degree of toughness. Rhodium, palladium, iridium, and osmium make steel very hard, but their use, from their cost, is confined mainly to the experimental laboratory. Platinum, in its malleable state, may be cut with a knife; but with steel it forms an alloy not to be touched with a file.

3424. Iron, Copper, and Zinc. An alloy consisting of 10 parts cast iron, 10 copper, and 80 zinc, does not adhere to the mould in casting, and it is of a beautiful lustre when filed and polished. The least fusible metals are melted first, and the zinc last, in making it.

3425. Ormolu, or Mosaic Gold. Copper and zinc, equal parts; melt together at the lowest possible temperature at which copper will fuse, and stir so as to produce a perfect admixture of the metals; then add gradually, small portions of zinc at a time, until the alloy acquires the proper color, which is perfectly white, while in the melted state. It must then be at once cast into figured moulds. This alloy should contain from 52 to 55 per cent. of zinc.

3426. White Metal. Lead, 10 ounces; bismuth, 6 ounces; and antimony, 4 drachms; or, 2 pounds antimony, 8 ounces brass, and 10 ounces tin.

3427. French Alloy for Forks and Spoons. This is a beautiful white metal, very hard, and taking a fine polish. It is composed of 69.8 parts of copper, 19.8 parts nickel, 5.5 of zinc, and 4.7 of cadmium.

3428. French Silver. The new French silver is apparently an improvement on the old-fashioned German silver, and it is stated to be applicable to all the purposes to which ordinary commercial silver is applicable. It is composed of copper, 56 per cent., nickel, 40.64, tungsten, 2.0, aluminum, 0.56. It is a white, ductile, malleable, tenacious, sonorous alloy; its specific gravity is nine-tenths that of silver, its metallic lustre superior to that of silver, and its fusibility less, probably on account of the tungsten it contains.

3429. The Alloys of Aluminum. We have to distinguish between alloys in which the aluminum predominates and such ones in which the other metals outweigh the latter. Those impart to the aluminum new properties. Iron and copper do not act injuriously if the admixture is not considerable. In regard to toughness, the union of 7 per cent. of iron can scarcely be distinguished from pure aluminum. Both metals easily combine with each other. Commercial aluminum mostly contains iron; it remains ductile with as much as 10 per cent. of copper, and when containing only half as much, it may be worked still easier. If alloyed with small quantities of zinc, tin, gold, or silver, the metal is rendered hard and more brilliant, but remains ductile. Especially recommended is the alloy consisting of 97 per cent. of aluminum, and 3 per cent of zinc. The alloy with 7 per cent. of tin can be worked well, but does not take a very fine polish, and cannot be cast, since a more fusible alloy with a large proportion of tin is separated. Aluminum and lead do not unite. The composition with 3 per cent. of silver and 97 of aluminum possesses a beautiful color, and in equal parts they yield an alloy of the hardness of bronze.

The union of 99 per cent. of aluminum and 1 of gold is, though hard, still ductile; its color is that of green gold. With 10 per cent. of gold, the composition is rendered crystalline. In combining aluminum with copper, the latter must be melted first, and the former added gradually in small portions at a time. A combination of 10 parts aluminum and 90 parts copper produces a fine aluminum bronze, which, however, is brittle after the first mixing; it increases in strength and tenacity only after successive fusions, but with the loss, each time, of a little aluminum. This bronze may be forged at a dull red heat without presenting flaws or cracks. Like copper, it is rendered more ductile by being heated and plunged into cold water.

3430. Copper and Aluminum for Journals. The most important alloy of aluminum is that composed of 90 per cent. of copper and 10 per cent. of aluminum. It possesses a pale gold color, a hardness surpassing that of bronze, is susceptible of taking a fine polish, and is easier forged than soft iron. This alloy has found a ready market, and, if less costly, would replace red and yellow brass. Its hardness and tenacity render it peculiarly adapted for the journals and bearings of machinery. Christofle, of Paris, who uses it for a journal for a polishing disk, found that it lasted six times longer than ordinary journals—that is, 18 months. There were 2200 revolutions made per minute. It is further stated, on good authority, that a journal of this new bronze, which was employed for the axle of a sewing machine, making 240 revolutions per minute, did excellent service for 1 year without indicating the least deficiency. Journals of ordinary bronze do not, as is well known, last over 5 months. When more than 10 per cent. of aluminum enters into the composition of the bronze, the alloy gradually becomes weaker and less malleable, and at length so brittle that it is easily pounded in a mortar.

3431. Oroide, or Artificial Gold. This material is manufactured largely in the United States into imitation jewelry and other articles, scarcely distinguishable from gold, except by the inferior gravity; and it is a matter of surprise to almost any one to learn that it does not contain a single grain of the precious metal. It is made by taking 100 parts of pure copper, 17 of pure tin, 6 of magnesia, 9 of tartar of commerce, 3.6 of sal-ammoniac, and 1.6 of unslacked lime. The copper is first melted, and the other substances (excepting the tin) added, a little at a time, and the whole well stirred for 30 minutes, so as to produce a perfect mixture, when the tin is thrown in and stirred round until melted. The crucible is then covered, and the fusion kept up for 25 minutes, and the scum taken off, when the substance is ready for use. It is malleable and ductile, and can be worked in any form, even into leaves like gold. The alloy may also be made by substituting granulated zinc for tin, but it will not retain its brilliancy so long as when tin is employed.

3432. Talmi Gold. A beautiful gold-colored alloy, sold under the above name, gives, on analysis: copper, 86.4; zinc, 12.2; tin, 1.1; iron, 0.3. The presence of the iron was probably accidental.

3433. Yellow Dipping Metal. Melt together 2 parts brass, 1 part copper, with a little old brass, and ½ ounce tin to every pound of copper. This alloy is almost of the color, etc., of gold coin.

3434. Alloy of the Standard Measure used by Government. This is composed of copper, 576 parts; tin, 59; yellow brass (22 copper to 1 of zinc), 48 parts.

3435. Dentists' Tin Alloys for Moulds. The gold plates on which artificial teeth are fastened, are fashioned to fit exactly to the mouth by being hammered between a mould and die, cast from a plaster model of the mouth. The plaster model is obtained from a mould of wax, pressed while soft into the cavities of the mouth, and allowed to harden. Duplicate moulds and dies are necessary, at different stages of the hammering, in order to obtain a perfectly fitting plate. The necessary characteristics of the metals used for the moulds and dies are fusibility, hardness, or toughness, and, especially for the moulds, a freedom from shrinkage in cooling. The metal usually employed for the dies consists of 8 parts tin, 1 part lead, and 1 part bismuth. This compound is much harder than tin, melts at a lower heat, shrinks little, or practically none, in casting; is tough and strong. It melts at about 330° Fahr. Although generally a harder and less fusible metal is used for the first swaging, this alloy is particularly convenient for taking duplicate dies for finishing. Its tenacity adapts it for cases of partial sets representing the teeth. The mould or counter-die metal is made by adding to 1 part of this mixture 6 parts of lead. The result is harder than lead, and does not yield like it under the blow, presenting a resistance sufficient to drive the plate up well against the die. Its shrinkage is but slight; it melts at from 450° to 460°. It is designed for use when the dipping process is resorted to. This consists in pouring the melted metal into an appropriately shaped vessel or mould, and pressing the plaster model into the metal before the moment of congelation. If used at the point of congelation, the plaster cast may be employed without previous baking; otherwise it should be baked to expel its water of crystallization.

3436. Hard Tin Alloys for Dentists' Moulds. The following formula affords a highly useful alloy, where toughness as well as hardness is essential: tin, 16 parts; antimony, 1 part; zinc, 1 part. This alloy is much harder than the preceding die metal, and equals it in tenacity, being suited for any kind of die; it requires a higher temperature to melt it, but it melts sooner than tin, or than the mould-metal mentioned in the preceding receipt, from a matrix of which a die may be taken by it with safety. It affords, in sand, a perfect die, does not shrink, and, whether poured into a sand or metal mould, comes out with a smooth, bright face. It is the best combination of these three metals for the purpose. But when dies are made of it from sand moulds, and a more fusible metal is needed for taking counter-dies or moulds from them, it may be had by a combination of 5 parts lead, 2 bismuth, and 1 tin; or, 5 parts lead, 3 to 4 bismuth, and 1 tin afford a still more fusible compound, although harder.

3437. Copper Alloys for Dentists' Moulds. A very hard and most valuable alloy for general use may be had by a mixture of tin, 12 parts; antimony, 2 parts; copper, 1 part. It is not much inferior to zinc in hardness, casts without sensible shrinkage, and makes a perfect and very handsome die, bright and smooth. It is less fusible than the hard tin die metal in last receipt, but may be used for taking dies from the mould-metal mentioned in No. 3435; but, as it melts at nearly the same temperature, this requires care. It will be found of value in connection with lead moulds made by dipping. (*See No.* 3435.) It is rather brittle for dies for partial sets representing the teeth, as these are liable to break on removing from the matrix; but it is abundantly strong enough for swaging purposes. In combining these metals (which may be done in an ordinary charcoal furnace, as it is by no means necessary to raise the heat to the melting point of copper), place the copper in a crucible and bring it to a red heat, then pour in the tin and antimony, melted, and cover the whole with charcoal dust, to prevent oxidation. The copper will soon liquefy, or dissolve, as it were, combining perfectly with the other metals, without further elevation of temperature. To guard better against volatilization of antimony, which takes place at a high red heat, it is well enough to add to the copper but half the tin at first, and when these are combined, add the antimony, and then the remaining tin. This also enables one to conduct the second melting in a larger crucible, or, indeed, in an iron ladle. It is best to let the melted mass cool down some, before pouring it from the crucible, as, if poured out at too high a heat, the alloy oxidizes. A larger proportion of antimony and zinc increases the hardness of the metal, but with a tendency to imperfect castings. If tin be used in larger quantity, the alloy is, of course, softer, and it shrinks when cast. The relative proportion of zinc and antimony, in respect to each other, may be somewhat varied, without material modification of the qualities of the compound; but, for the best results, the sum of these two metals should hold to the quantity of tin employed the ratio of about 1 to 8. For fluidity, an excess of antimony over copper appears to be requisite. For non-shrinkage, the joint amount of antimony and copper should be to the quantity of tin as about 1 to 4; as, for example, 8 parts tin, 1 antimony, 1 copper; or, 10 tin, 1½ antimony, 1 copper; or, 12 tin, 2 antimony, 1 copper. For taking counter-dies or moulds from dies of the last named alloys, a suitable metal, fusible at about 380° Fahr., is had by a mixture of 3 parts lead, 1 part bismuth, and not over $\frac{1}{16}$ part tin. It is wonderful how small a quantity of tin serves to improve the alloys of lead and bismuth, giving them a white, clear lustre, preventing oxidation, promoting fusibility—in short, producing almost a new metal.

3438. Cadmium Alloys for Dentists' Moulds. By the use of cadmium we may produce still harder alloys than any of the preceding, possessing in an equal degree every other desirable quality. Thus, 10 parts of tin, 1 part of antimony, 1 of copper, and 1 of cadmium, produce a compound which has about the hardness of zinc; it casts perfectly, and is nearly all that could be desired, except that, like the copper die metals, it is rather brittle for certain castings. (*See No.* 3437.) Substituted for copper in these connections, cadmium appears to confer greater hardness and toughness, and, up to a certain point, promotes fusibility. 9 parts of tin, 1 part of antimony, and 1 part cadmium, furnish a very hard and tough metal of a compact, homogeneous structure, which casts without shrinkage, forming a perfect die with a smooth, bright face. It melts at about the melting point of tin. In the employment of cadmium, care must be taken not to subject it to a heat high enough to volatilize it. To avoid this danger, it is best to unite the other metals first, and then add the cadmium at a heat barely sufficient to melt it. The great objection to this metal is its expensiveness.

3439. Alloy of Nickel and Copper. A mixture of 1 part nickel and 2 parts copper produces a grayish-white metal, tenacious, ductile, and moderately fusible.

3440. Alloys of Platinum and Copper. A compound of 1 part platinum and 4 parts copper is of a yellow-pink color, hard, ductile, and susceptible of a fine polish.

An alloy of 3 parts platinum and 2 parts copper is nearly white, very hard, and brittle.

3441. French Bell Metal. The metal used in France for hand-bells, clock bells &c., is made of 55 to 60 parts copper, 30 to 40 parts tin, and 10 to 15 parts zinc.

3442. Red Tombac. Put into a crucible 5½ pounds copper; when fused add ½ pound zinc; these metals will combine, forming an alloy of a reddish color, but possessing more lustre than copper, and also greater durability.

3443. White Tombac. When copper is combined with arsenic, by melting them together in a close crucible, and covering the surface with common salt, to prevent oxidation, a white brittle alloy is formed.

3444. Speculum Metal for Telescopes. Melt 7 pounds of copper, and when fused add 3 pounds zinc and 4 pounds tin. These metals will combine to form a beautiful alloy of great lustre, and of a light yellow color, fitted to be made into specula for telescopes. Mr. Mudge used only copper and grain tin, in the proportion of 2 pounds of the former to 14½ ounces of the latter.

3445. Babbitt's Anti-Attrition Metal. Melt 4 pounds copper, add by degrees 12 pounds best quality Banca tin, 8 pounds regulus of antimony, and 12 pounds more tin while the composition is in a melted state. After the copper is melted and 4 or 5 pounds of tin have been added, the heat should be reduced to a dull red, to prevent oxidation; then add the remainder of the metal as above. In melting the composition, it is better to keep a small quantity of powdered charcoal on the surface of the metal. The above composition is called hardening. For lining the boxes, take 1 pound of this hardening and melt it with 2 pounds of Banca tin, which produces the lining metal for use. Thus, the proportions for lining metal are 4 pounds copper, 8 pounds regulus of antimony, and 96 pounds Banca tin.

3446. Gongs and Cymbals. The secret method employed by the Chinese for working the hard brittle bronze used for making gongs and cymbals, seems to be solved by the fact that the bronze of which these instruments are made, consisting of copper alloyed with about 20 per cent. of tin, and almost as brittle as glass at ordinary temperatures, becomes as malleable as soft iron, if worked at a dull red heat. This discovery was recently made in Paris, by M.M. Julien and Champion, the result of experiments at the Paris Mint.

3447. Phosphorus Bronzes. A great advance has lately been made in the construction of bronzes, by the addition of a small percentage of phosphorus, although the precise function of this substance has not been hitherto well understood. According to Levi and Kunzel, however, one cause of the inferiority in bronze consists in the constant presence of traces of tin in the state of an oxide, which acts mechanically by separating the molecules of the alloy, thus interposing a substance which in itself has no tenacity. The addition of phosphorus reduces this oxide, and renders the alloy much more perfect, improving its color, its tenacity, and all its physical properties. The grain of its fracture resembles more that of steel, its elasticity is much augmented, and its resistance to pressure sometimes more than doubled. Its durability is greater, and, when melted, it is of greater fluidity, and fills the mould in its finest details.

3448. Fontainemoreau's Bronzes. There is a kind of bronze known as Fontainemoreau's bronze, in which zinc predominates. It is said to answer well for chill moulding, that is, for pouring in metal moulds, by which method it is rendered very homogeneous. The crystalline nature of the zinc is entirely changed by the addition of a small proportion of copper, iron, &c. The alloy is hard, close-grained, and resembles steel. Moreover, it is easier to file than either zinc or copper. The following table presents the proportions in use:

Zinc.	Copper.	Cast Iron.	Lead.
90	8	1	1
91	8	0	1
92	8	0	0
92	7	1	0
97	2½	½	0
97	3	0	0
99½	0	½	0
99	1	0	0

3449. Use of Petroleum in Turning Metals. A bronze composed of seven parts of copper, 4 of zinc, and 1 of tin, has been found to be so hard as to be difficult to work, and yet of considerable value in certain ways when worked. Various methods have been attempted, aiming at effecting a ready working of this alloy, and M. Bechstein has recently, by soaking the alloy in petroleum, attained this desirable end.

3450. To Clean Bronze. It was observed in Berlin that those parts of a bronze statue which were much handled by the public retained a good surface, and this led to the conclusion that fat had something to do with it. An experiment was therefore tried for some years with four bronzes. One, says our authority—Chambers' Journal—was coated every day with oil, and wiped with a cloth; another was washed every day with water; the third was similarly washed, but was oiled twice a year; and the fourth was left untouched. The first looked beautifully; the third, which had been oiled twice a year, was passable; the second looked dead; and the fourth was dull and black.

3451. Engestroom Tutania. Melt together 4 parts copper, 8 parts regulus of antimony, and 1 part bismuth. When added to 100 parts of tin, this compound will be ready for use.

3452. Tutenag. Melt together 8 parts of copper, 5 parts of zinc, and 3 parts of nickel.

3453. Kustitien's Metal for Tinning. To 1 pound of malleable iron, at a white heat, add 5 ounces regulus of antimony, and 24 pounds of the purest Molucca tin. This alloy polishes without the blue tint, and is free from lead or arsenic.

3454. Expansion Metal. Melt together 9 parts of lead, 2 parts of antimony, and 1 part bismuth.

3455. Fluid Alloy of Sodium and Potassium. If 4 parts sodium are mixed with 2½ potassium, the alloy will have exactly the appearance and consistency of mercury, remaining liquid at the ordinary temperature of the air.

3456. Fusible Alloys. Bismuth, 8 parts; lead, 5 parts; tin, 3 parts; melt together. Melts below 212° Fahr. Or: Bismuth, 2 parts; lead, 5 parts; tin, 3 parts. Melts in boiling water. Or: Lead, 3 parts; tin, 2 parts; bismuth, 5 parts; mix. Melts at 197° Fahr. The above are used to make toy-spoons, to surprise children by their melting in hot tea or coffee; and to form pencils for writing on asses' skin, or paper prepared by rubbing burnt hartshorn into it. The last may be employed as an anatomical injection, by adding (after removing it from the fire), 1 part quicksilver (warm). *Liquid* at 172°; *solid* at 140° Fahr.

3457. Wood's Patent Fusible Metal melts between 150° and 160° Fahr. It consists of 3 parts cadmium, 4 tin, 8 lead, and 15 bismuth. It has a brilliant metallic lustre, and does not tarnish readily.

3458. The Most Fusible Alloy. There is an alloy of bismuth, tin, and lead, which, from its very low melting point, is called *fusible metal*. (*See No.* 3457). Dr. Von Hauer has found, however, that the addition of cadmium to the alloys of the above mentioned metals reduces their melting point still lower. An alloy of 4 volumes cadmium, with 5 volumes each tin, lead, and bismuth, is quite liquid at 150° Fahr. In parts by weight, the above would be 224 parts cadmium, 517½ lead, 295 tin, and 1050 bismuth. (*See No.* 52). An alloy of 3 volumes of cadmium with 4 each of tin, lead, and bismuth, fuses at 153½° Fahr, and an alloy of 1 equivalent of cadmium with two equivalents each of these three other metals, at 155½°, which is also the fusing point of an alloy of 1 part each of all the four metals. Dr. von Hauer made these alloys by fusing their ingredients in a covered porcelain crucible at the lowest practicable temperature. They all become pasty at lower temperatures than those given above; the temperatures quoted are those at which the alloys are perfectly fluid. It should be added that, unfortunately, all these alloys very rapidly oxidize when placed in water.

3459. Table of Alloys of Tin and Lead and their Melting Heats.

Tin.	Lead.	Bismuth.	Fahr.
1	25	0	558°
1	10	0	541
1	5	0	511
1	3	0	482
1	2	0	441
1	1	0	370
1½	1	0	334
2	1	0	340
3	1	0	356
4	1	0	365
5	1	0	378
6	1	0	381
4	4	1	320
3	3	1	310
2	2	1	292
1	1	1	254
1	2	2	236
5	3	3	202
3	5	8	197

Fluxes.

Fluxes. This term is applied to substances of easy fusibility, which are added to others more refractory, to promote their fusion. Various fluxes are given in other portions of this work (*see Soldering and Enamels*), but the principal fluxes are the following:

3461. Black Flux. Cream of tartar, 2 parts; nitre, 1 part; powder, mix, and deflagrate by small quantities at a time, in a red hot crucible. This is merely carbonate of potash, mixed with charcoal in a finely-divided state. It is used for smelting metallic ores, and exercises a reducing action, as well as promoting the fusion. (*See No.* 11.)

3462. White, or Cornish Refining Flux. Cream of tartar and nitre, equal parts; deflagrate as last.

3463. Morveau's Reducing Flux. Powdered glass (free from lead), 8 parts; calcined borax and charcoal, each 1 part; all in fine powder, and triturated together thoroughly. Used as *black flux*. (*See No.* 3461.)

3464. Flux for Reducing Lead Ore. Take 6 parts red argol, 4 parts nitre, 2 parts borax, and 1 part fluorspar; pulverise well and mix thoroughly.

3465. Cornish Reducing Flux. Crude tartar, 10 parts; nitre, 4 parts; borax, 3 parts. Mix as the last.

3466. Crude Flux. Same as *black flux*, (*see No.* 3461), omitting the deflagration.

Used for reducing. (*See No.* 26.)

3467. Liebig's Flux. Carbonate of soda (dry, *see No.* 2065), and cyanide of potassium, 1 part each. Used for reducing arsenious acid.

3468. Fresenius' Flux. Carbonate of potassa (dry), (*see No.* 2065), 3 parts; cyanide of potassium, 1 part. For the arsenical compounds.

3469. Christison's Flux for Arsenic. Carbonate of soda, (crystallized). 8 parts; charcoal (in fine powder), 1 part; mixture is gradually to be heated to redness.

3470. Flux for Copper. Sal-enixum (the refuse from aquafortis), to be obtained at most of the chemical works at a trifling cost, is strongly recommended by Larkin as a general flux for copper foundings, particularly where large masses of copper have to be melted prior to adding the tin and zinc. Nothing is equal to it. This, with charcoal, surpasses everything else.

3471. Various Fluxes. Borax, tartar, nitre, sal-ammoniac, common salt, limestone, glass, fluorspar, resin, and several other substances are used as fluxes in fusing metals, and soldering. On the large scale crude tartar is employed. (*See No.* 3472.)

Soldering and Welding.

Soldering is the art of uniting the surfaces of metals by partial fusion, and the insertion of an alloy between the edges, which is called solder, it being more fusible than the metals which it unites. Solders are distinguished as hard and soft, according to their difficulty of fusion. Hard solders usually melt only at a red heat, but soft solders fuse at lower temperatures. In order to join metals, it is obvious that a solder must be used that melts at a lower temperature than the metals to be joined; but it may also be necessary that it approach as nearly as possible to them in point of hardness; and occasionally, as is especially the case with jewelry, similarity of color is an object. The heat requisite for soldering small articles, such as jewelry, etc., is usually obtained by employing a common blowpipe; as by its use a sudden heat may be concentrated on a small point. Where a larger surface has to be heated, the flame of a spirit lamp is used. For brazing, or uniting larger objects with hard solder, a furnace, or, if necessary, a forge, may be employed. In working tin plates, the solder is applied and fused by a heated copper tool called a soldering-iron. The surfaces of parts to be joined by soldering must be perfectly clean; and in order to ensure this, as well as to counteract the oxidization which most metals undergo when heated, a flux is used (*see No.* 3479), which neutralizes or removes these otherwise serious impediments, securing a firm joint.

3473. To Make Soldering Fluid for Soft Solder. Into muriatic acid put small pieces of zinc until all bubbling ceases; some add 1 ounce sal-ammoniac to each pound of the liquid.

3474. Neutral Soldering Fluid. Dissolve zinc in muriatic acid as above, then warm the solution and add sufficient oxide or carbonate of tin in powder to neutralize it. This prevents the fluid from corroding the seams.

3475. Soldering Liquid. Soldering liquid is made by taking hydrochloric acid, $\frac{1}{4}$ pint; granulated tin, $1\frac{1}{2}$ ounce; dissolve and add some common solder and hydrochlorate of ammonia.

3476. Flux for Soldering. For common purposes powdered resin is generally used. Stearic acid, obtained from the candle factories, makes a good flux for fine tin work.

3477. Flux for Soldering Iron or Steel. Dissolve chloride of zinc in alcohol.

3478. Flux for Soldering Steel. This answers perfectly when the fracture is an old one. To a saturated solution of zinc in 1 pint muriatic acid, add 4 ounces pulverized sal-ammoniac; boil it for 10 minutes; put it, when cold, in a well corked bottle. The boiling must be done in a copper vessel.

3479. Soft Soldering. The solder is an alloy of 2 parts tin to 1 part lead, fusible at 340° Fahr.; or, for cheapness, the proportion is sometimes 3 to 2, fusible at 334°. This substance is applied with a hot copper tool called a soldering-iron, or by blowpipe flame. Heat, however, causes the edges of the metal to oxidize; therefore the edges are covered with a substance having a strong attraction for oxygen, and disposing the metal to unite to the solder at a low temperature. Such substances are called fluxes, and are chiefly borax, resin, sal-ammoniac, muriate of zinc, Venice turpentine, tallow, or oil.

3480. Flux for Soldering Brass. For brass or other similar alloy, resin, sal-ammoniac, and muriate of zinc are the proper fluxes. Should the work be heavy and thick, the soldering requires to be done over a charcoal fire in order to keep the tool heated within proper limits. It is as well to tin the surfaces before soldering; in some cases simply dipping into a pot of melted solder effects the purpose, but the dip must be done instantly to be effective.

3481. Flux for Soldering Zinc. Zinc is difficult to solder, from the fact that it is apt to withdraw the tin from the soldering bolt, zinc and copper having a stronger affinity for each other than tin and copper. The proper flux is muriate of zinc, made by dissolving small bits of zinc or zinc drops in muriatic acid mixed with an equal bulk of water.

3482. Flux for Soldering Tin and Lead. Tin and lead require resin or oil as the flux.

3483. Flux for Soldering Pewter. Pewter requires a flux of oil, and may, in addition to the soldering-iron process, be soldered by a current of heated air.

3484. Flux for Soldering Britannia Metal. Britannia metal should have muriate of zinc for a flux, and be soldered by the blowpipe.

3485. To Solder Iron. Iron requires the surfaces to be tinned over before being soldered; the method is given in No. 3515.

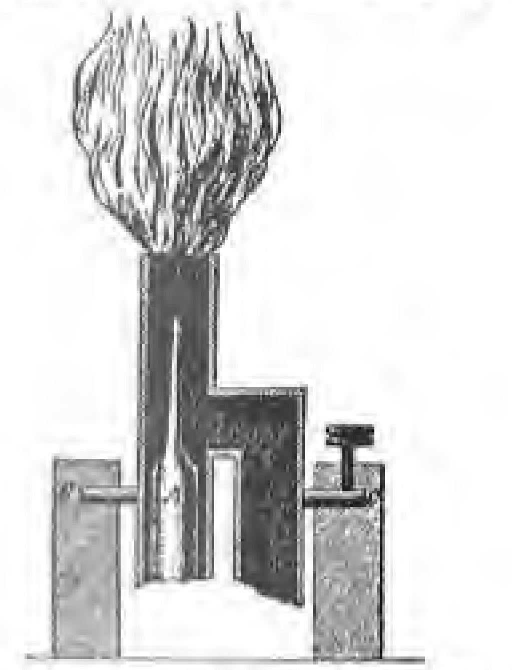
3486. To Soft Solder Small Articles. Join together the parts to be soldered, first moistening them with soldering fluid (*see No.* 3473), lay a small piece of solder over the joint and apply heat, either over a spirit flame, or by means of the blowpipe, as the case may be. The heat should be withdrawn at the moment of fusion, otherwise the solder may become brittle.

3487. To Soft Solder Smooth Surfaces. Where two smooth surfaces are to be joined, moisten the surfaces with soldering fluid (*see No.* 3473), and lay a piece of tin foil between them, press them together closely, and apply heat sufficient to fuse the tin foil.

3488. Hard Soldering or Brazing. The alloy used in hard soldering is generally made of equal parts of copper and zinc; much of the zinc, however, is lost in the process, so that the real proportion is not equal parts. The alloy is heated over a charcoal fire, and broken to granulations in an iron mortar. A different proportion is used for soldering copper and iron, viz.: 3 zinc to 1 copper. The commercial name is "spelter solder."

3489. Flux for Spelter Solder. The flux employed for spelter solder is borax, which can either be used separately, or mixed, by rubbing to a cream, or mixed with the solder in a very little water.

3490. To Hard Solder. When the work is cleaned, bound, fluxed, and speltered, the whole is subjected to a clear charcoal or coke fire; or, what is now becoming far more general, convenient, cleanly, and manageable, a bellows blowpipe. The air passes from a bellows propelled by the foot through *A* (*See Engraving.*) The gas passes through *B*,



and the flame can be directed to any point, on account of its being hinged at *C C*. The flame can be extended by using several stands, or by constructing several burners on one stand. The heat is much greater than from charcoal, can be regulated at pleasure, and kept at the same temperature for any given time. In the process of hard soldering, the water should be driven off by gentle heat; the fusion of the flux soon follows; a glassy substance appears after the froth, which, in its turn, is replaced by the alloy in red liquid form; the blue flame from the ignited zinc informs the operator that the solder now fuses, so that, as soon as the work is flushed with solder, it must be withdrawn, allowed to set, and cooled in water.

3491. To Make Solder. The mixture of the metals is performed by melting them together in the same manner as for alloys (*see No.* 3347), with the aid of a flux. The metals employed should be pure, especially silver, as silver coin makes the solder too hard.

3492. Solder for Gold. Take 12 parts pure gold, 2 parts pure silver, and 2 parts copper.

3493. Solder for Silver. Take 5 parts pure silver—not silver coin—6 parts brass, and 2 parts zinc. Or, 2 parts silver, 1 part common pins. This is an easy flowing solder. Use a gas jet to solder with.

3494. Hard Solder. Take 2 parts copper and 1 part zinc. Or, equal parts of copper and zinc. (*See No.* 3488.)

3495. Solder for Silver. Take 19 parts fine silver, 1 part copper, and 10 parts brass.

3496. Silver Solder. Melt together 34 parts, by weight, silver coin, and 5 parts copper; after cooling a little, drop into the mixture 4 parts zinc, then heat again.

3497. Fine Silver Solder. Melt in a clean crucible, 19 parts pure silver, 10 parts brass, and 1 part copper; add a small piece of borax as a flux.

3498. Solder for Copper. Same as hard soldering. (*See No.* 3488.)

3499. Solder for Tin. Take 4 parts pewter, 1 part tin, and 1 part bismuth. Use powdered resin when soldering.

3500. Fine Soft Solder. Take 2 parts tin and 1 part lead. Used for soldering tin plates, and tinning copper. Add resin as a flux when melting.

3501. Very Soft Solder. Equal parts of tin, lead, and bismuth.

3502. Solder for Pewter. Take 2 parts tin, 1 part each of lead and bismuth.

3503. Glaziers' Solder. Take 3 parts lead and 1 part tin. This melts at 500° Fahr.

3504. Solder Fusible in Boiling Water. Take 1 part tin, 1 part lead, and 2 parts bismuth.

3505. Plumbers' Solder. Take 1 part bismuth, 5 parts lead, and 3 parts tin.

3506. Solder for Lead. Take 2 parts lead and 1 part tin. This is good, if, when a small quantity is poured on a table, little bright spots rise as it cools. When soldering with this, use powdered resin.

3507. Brass Solder. Take 12 parts brass, 6 parts zinc, and 1 part tin.

3508. Strong Brass Solder. Take 3 parts brass and 1 part zinc.

3509. To Solder Fine Brass Work. Wet the parts with a strong solution of sal-ammoniac, apply tin foil between them, and heat no more than is necessary to fuse the tin.

3510. To Solder Iron. Apply good tough brass (*see No.* 3358) with borax mixed with water to the consistence of cream. (*See No.* 3486.)

3511. Solder for Joining Steel. This is better than the usual brass solder, for uniting cast-steel, &c., as it fuses at a lower temperature; and, being whiter in appearance, renders the seams less observable. Take 19 parts, by weight, fine silver; 1 part copper, and 2 parts brass; melt them under a coat of charcoal dust.

3512. Brass Solder for Brazing Iron or Steel. Thin plates of brass are to be melted between the pieces that are to be joined. If the work be very fine—as when two leaves of a broken saw are to be brazed together—cover it with pulverized borax, dissolved in water, that it may incorporate with some brass powder which is added to it; the piece must be then exposed to the fire without touching the coals, and heated till the brass is seen to run.

3513. To Solder Ferrules for Tool Handles, &c. Take the ferrule, lap round the jointing a small piece of brass wire, then just wet the ferrule, scatter ground borax on the joining, put it on the end of a wire, and hold it in the fire till the brass fuses. It will fill up the joining, and form a perfect solder. It may afterwards be turned in the lathe.

3514. To Tin Iron for Soldering, &c. Drop zinc shavings into muriatic (hydrochloric) acid, until it will dissolve no more; then add ¼ its bulk of soft water. Iron, however rusty, will be cleansed by this solution, and receive from it a sufficient coating of zinc for solder to adhere to. (*See No.* 3642.)

3515. To Solder Grey Cast-Iron. First dip the castings in alcohol, after which, sprinkle muriate of ammonia (sal-ammoniac) over the surface to be soldered. Then hold the casting over a charcoal fire till the sal-ammoniac begins to smoke, then dip it into melted tin (not solder). This prepares the metal for soldering, which can then be done in the ordinary way.

3516. Solder for Iron. Fuse together 67 parts copper and 33 parts zinc. Or: 60 parts copper and 40 parts zinc.

3517. Hard Solder for Copper or Brass. Take 13 parts copper and 1 part zinc. Or: 7 copper, 3 zinc and 2 tin.

3518. Solder for Brass in General. Take 4 parts of scraps of the metal to be soldered, and 1 part zinc.

3519. To Make Solder-Drops. Melt the solder, and pour it in a steady stream of about ¼ inch in diameter, from a height of 2 or 3 inches, into cold water; taking care that the solder, at the time of pouring, is no hotter than is just necessary for fluidity.

3520. Aluminum Solder. Mourey employs five different solders, being different proportions of zinc, copper, and aluminum. The copper is melted first, the aluminum is then added in 3 or 4 portions; when the whole is melted, it is stirred with an iron rod. The crucible is then withdrawn from the fire, the zinc gradually stirred into the mass, and the whole poured into ingot shaped moulds, previously wiped out with benzine. The parts given in the following proportions are by weight.

1.—80 parts zinc,	8 parts copper,	12 parts aluminum.	
2.—85 " "	6 " "	9 " "	
3.—88 " "	5 " "	7 " "	
4.—90 " "	4 " "	6 " "	
5.—94 " "	2 " "	4 " "	

3521. To Solder Aluminum. The selection of either of the above solders depends upon the nature of the object. In order to quicken its fusion on the metal, a mixture of 3 parts balsam of copaiba and 1 part Venice turpentine is made use of; otherwise the operation is performed in exactly the same manner as in the brazing of other metals. The aluminum solder is spread without delay on the previously heated surfaces to be fastened together. In heating, the blue gas flame or the turpentine blast lamp is employed. The more and oftener the solder is spread over the surface, the better it is.

3522. Aluminum Solder. If soft solder is fused with one-half, one-fourth, or one-eighth of its weight of zinc amalgam (to be made by dissolving zinc in mercury, *see No.* 3539), a more or less hard and easily-fusible solder is obtained, which may be used to solder aluminum to itself or to other metals.

3523. Welding Powder for Iron and Steel. For welding iron and steel a composition has lately been patented in Belgium, consisting of iron filings, 40 parts; borax, 20 parts; balsam of copaiba, or some other resinous oil, 2; and sal-ammoniac, 3 parts. They are mixed, heated, and pulverized. The process of welding is much the same as usual. The surfaces to be welded are powdered with the composition, and then brought to a cherry-red heat, at which the powder melts, when the portions to be united are taken from the fire and joined. If the pieces to be welded are too large to be both introduced at the same time into the forge, one can be first heated with the welding powder to a cherry-red heat, and the others afterwards to a white heat, after which the welding may be effected.

3524. Welding Composition for Cast Steel. Take borax, 10 parts; sal-ammoniac, 1 part; grind or pound them roughly together, then fuse them in a metal pot over a clear fire, taking care to continue the heat until all spume has disappeared from the surface. When the liquid appears clear, the composition is ready to be poured out to cool and concrete; afterwards, being ground to a fine powder, it is ready for use. To use this composition, the steel to be welded is first raised to a bright yellow heat, it is then dipped among the welding powder, and again placed in the fire, until it attains the same degree of heat as before; it is then ready to be placed under the hammer.

3525. Welding Powder. For iron or steel, or both together, calcine and pulverize together 100 parts iron or steel filings, 10 sal-ammoniac, 6 borax, 5 balsam copaiba. One of the pieces is to be heated red, carefully cleaned of scale, the composition is to be spread upon it, and the other piece applied at a white heat and welded with the hammer.

3526. Welding Composition. Fuse borax with $\frac{1}{16}$ its weight sal-ammoniac, cool, pulverize, and mix with an equal weight of quicklime, when it is to be sprinkled on the red hot iron and the latter replaced in the fire.

3527. Welding Composition. Take 15 parts borax, 2 of sal-ammoniac, and 2 of prussiate of potash. Being dissolved in water, the water should be gradually evaporated at a low temperature.

3528. Welding Composition. Mix 10 parts borax with 1 part sal-ammoniac; fuse the mixture, and pour it on an iron plate. When cold, pulverize it, and mix it with an equal weight of quicklime, sprinkle it on iron heated to redness, and replace it in the fire. It may be welded below the usual heat.

3529. Compound for Welding Steel. The following composition is said to be superior to borax for welding steel. Mix coarsely powdered borax with a thin paste of Prussian blue; then let it dry. The combination seems to be a rational one.

3530. Antimonoid. A welding powder, named antimonoid, has been in use for some time past in Germany, and found to be of great efficiency. The formula for its preparation has, until lately, been kept a secret; it consists of 4 parts iron turnings, 3 parts borax, 2 parts borate of iron, and 1 of water.

3531. Fluxes for Soldering and Welding.

For Iron or steel	Borax or sal-ammoniac.
" Tinned iron	Resin or chloride of zinc.
" Copper and brass	Sal-ammoniac or chloride of zinc.
" Zinc	Chloride of zinc.
" Lead	Tallow or resin.
" Lead and tin pipes	Resin and sweet oil.

Amalgams. Substances formed by mixing quicksilver with another metal. Alloys containing quicksilver. Mercury unites with most of the metals by mere contact, forming amalgams. These are employed for various purposes in the arts, as silvering, gilding, coating mirrors, &c.

3533. Amalgam of Gold for Gilding Brass, Copper, &c. Place one part grain or leaf gold in a small iron saucepan or ladle, perfectly clean, then add 8 parts mercury, and apply a gentle heat, when the gold will dissolve; agitate the mixture for one minute with a smooth iron stirrer, and pour it out on a clean plate or stone slab. When cold it is ready for use.

3534. To Gild with Gold Amalgam. For gilding brass, copper, &c. The metal to be gilded is first rubbed over with a solution of nitrate of mercury, and then covered with a very thin film of the amalgam. On heat being applied, the mercury volatilizes, leaving the gold behind. A much less proportion of gold is often employed than the above, where a very thin and cheap gilding is required, as, by increasing the quantity of the mercury, the precious metal may be extended over a much larger surface. (*See No.* 3394.)

3535. Amalgam of Silver for Silvering Metals. Prepare in the same way as amalgam of gold, but substitute silver instead of gold. (*See No.* 3533.)

3536. To Obtain Pure Silver in Powder. The best process to obtain pure silver in powder, is by adding copper to a dilute solution of silver in nitric acid, until all action ceases. The silver is precipitated in a fine powder. Before using the silver powder to prepare amalgam, it must be thoroughly washed until the water ceases to have any acid taste, or litmus paper is unchanged by it. (*See Nos,* 3212, *&c.*) The silver in this form, besides being necessarily purer, amalgamates more readily with the quicksilver.

3537. To Make a Solution of Silver. Dissolve a silver coin in *slightly* diluted nitric acid. Mexican coin is preferable, because it is purer. (*See No.* 3213.)

3538. Amalgam for Silvering the Insides of Convex Mirrors, Glass Globes, &c. Lead and tin, of each 2 ounces; bismuth, 2 ounces; mercury, 4 ounces. Add the mercury to the rest in a melted state and remove from the fire; mix well with an iron rod. This amalgam melts at a low heat, and is employed for silvering the insides of hollow glass vessels, globes, convex mirrors, &c. The glass, being well cleaned, is carefully warmed, and the amalgam, rendered fluid by heat, is then poured in, and the vessel turned round and round, so that the metal may be brought in contact with every part of the glass which it is desired to cover. At a certain temperature this amalgam readily adheres to glass. (*See Nos.* 3545, *and* 3614.)

3539. To Make Zinc Amalgam for Electrical Machines. Melt 2 ounces zinc in a ladle, remove from the fire, and stir into it 5 ounces mercury previously heated. Stir till cold, and then powder it. Keep it in a tightly corked bottle.

3540. Improved Electric Amalgam. It is well known that a deposit of moisture greatly interferes with the action of electrical machines, experiments often wholly failing from this cause, especially in the winter season. Mr. F. Dietlen, of Klagenfurt, has devised a method by which he obviates this difficulty, consisting simply in a modification of the amalgamation of the rubber cushion. For this purpose he pours petroleum over zinc filings, and, adds an equal quantity of mercury (though an excess of mercury facilitates the process). The mixture is then brought, by working together in a mortar, to the condition of a homogeneous paste, and pressed between a double cloth. A soft mass is thus obtained, which, however, soon hardens; but which, being finely pulverized and mixed with a proper quantity of grease, is spread upon the rubber cushion. This makes the surface quite glossy, and, when the glass disk has previously been wiped with a piece of cotton slightly impregnated with petroleum or benzine, will develop electricity abundantly, even in damp localities where the usual arrangement fails.

3541. Boettger's Amalgam for Electrical Machines. Boettger recommends a mixture of 2 parts (by weight) of pure zinc, while melted, to be mixed with 1 part of mercury. This should be kept in pieces in a well-stoppered flask, and is said to be superior to the amalgam made of 2 parts mercury, 1 zinc, and 1 tin.

3542. Tin Amalgam. Amalgam of tin forms readily by introducing the solid metal into the mercury. In this way hexagonal crystalline formations have been observed; there is always a decided contraction in bulk. The hard amalgam of tin obtained by passing the liquid amalgam through fine leather, then drying, and afterwards rubbing under water, forms one of the plastic cements for filling teeth. (*See No.* 3553). It hardens within a few days, and is, besides, used for hermetically closing glass tubes. Mixed with a little silver amalgam it is a less plastic mass and requires a little more mercury, but it hardens much sooner.

3543. Copper Amalgam. Copper amalgam is best obtained by first precipitating metallic copper in a fine state of division from a solution of 3 ounces of blue vitriol in a quart of water mixed with an ounce of oil of vitriol, by means of clean wrought iron; then, after washing it thoroughly with hot water, moistening the powder with a solution of proto-nitrate of mercury, and finally incorporating it under water in a mortar with the required quantity of mercury. This amalgam, like the hard amalgam of tin, has the property of being softened and rendered plastic by mere trituration with a pestle. The proportions are generally 3 parts of copper to 7 of mercury.

3544. Tin and Cadmium Amalgam. Similar properties to tin and copper amalgams belong to the compound amalgam of tin and cadmium, which are fused together in the proportion of 2 to 1 and mixed with warmed mercury in excess, which latter is removed by pressure when cold. (*See No.* 3549.)

3545. Amalgam for Silvering Glass Ornaments. The silver coating of glass beads and those large sized glass ornaments now in fashion, is produced by shaking within them an amalgam composed of 8 parts bismuth, 5 of lead, 3 of tin, and from 7 to 9 parts of mercury. (*See No.* 3538.) A mixture of 2 parts each tin and bismuth and 1 of mercury, when powdered, is used for painting as imitation silver bronzes.

3546. Amalgams of the Alkaline Metals. The amalgams of the alkaline metals are remarkable for their hardness, though the metals sodium and potassium themselves are quite soft at the ordinary temperature. One per cent. of sodium in mercury produces an amalgam which is liquid, but still quite thick, and ¼ per cent. of potassium renders the mercury still more so. A very hard compound is that consisting of 200 parts of mercury, 10 of potassium, and 1 of sodium. By means of the alkaline amalgams, most other mercurial alloys may be produced, by introducing them into the solution of other metals. Zinc amalgam is likewise used for the purpose.

3547. Amalgam of Fusible Metal. Fusible metal forms an amalgam with $\frac{1}{10}$ of its weight of mercury, which fuses far below the boiling point of water; cadmium increases the fusibility still more. A mixed amalgam for injecting anatomical preparations, which is hard at ordinary temperature, but becomes soft at 150°, and fuses at 176° Fahr., consists of 20 parts of bismuth, 12 of lead, 7 of tin, and 4 of mercury. (*See Nos.* 3456, *&c.*)

3548. Amalgam for Varnishing Plaster Casts. Melt together 1 part each tin and bismuth, and stir in thoroughly 1 part mercury. When cool, pound the amalgam with white of egg, forming a metallic paint which may be laid on with a brush.

3549. Evans' Tooth Amalgam. Take of pure grain tin, 2 parts; cadmium and bees' wax, of each 1 part; melt them together in a porcelain crucible at a heat not exceeding 600° Fahr., and cast the alloy so as to form a small ingot, which, when cold, must be reduced to filings. For use, a small quantity of these filings is formed into an amalgam with quicksilver, the excess of the latter is squeezed out through a piece of chamois leather, and the amalgam at once applied to the tooth. (*See No.* 3550.) This cement is recommended by Mr. Evans as very durable and unobjectionable. Its color is intermediate between that of silver and tin, but it is said not to darken so readily as the simple amalgams of those metals. (*See No.* 3544.)

3550. Dentists' Amalgam, or Gold Stopping. The dentists, in preparing and using this, commonly proceed as follows: A little pure grain-gold is heated in a bright iron ladle (or capsule), and enough pure mercury added to render it of a doughy consistence at the temperature of hot water. When it has become cold, the excess of mercury, if any, is removed by pressure in a piece of chamois leather. In using it, a little of the amalgam, as hot as can be borne, is kneaded in the hand, and at once pressed into the cavity of the tooth, where it gradually hardens. It is an excellent and durable stopping, and is, perhaps, preferable to all others, except the diamond tooth cement (*see Index*) for filling up cracks and cavities in the enamel, particularly of the front teeth, on account of its color and the ease of its application.

3551. Dentists' Amalgam of Silver is used in the same way as the last; but its color is less natural, and is apt to be blackened by the sulphur in the secretions of the mouth and the food. (*See No.* 3535.)

3552. Dentists' Amalgams of Tin and Zinc are also employed as tooth cement, but are inferior in color to, darken sooner, and possess less durability, than that of silver.

3553. Alloy for Filling Teeth. An alloy, which is sold in commerce in the shape of large, almost white filings, shows upon analysis the following composition: Tin, 611; silver, 388; copper, 1. The alloy is to be amalgamated before use by warming it in a spoon with a little mercury. The combination takes place rapidly, and the amalgam, while still warm, is pressed in a piece of soft leather, whereby the excess of mercury is removed. It is now far preferable to the celebrated copper amalgam, as it retains its white color in the mouth, while the other turns dark. The hardness is a little less than that of the copper amalgam. (*See No.* 3542.)

3554. To Recover the Silver Alloy from Dentists' Amalgam. The silver alloy may be easily obtained from scraps of dentists' amalgam in the following manner: Provide 2 crucibles of different sizes, so that the smaller one, inverted, will rest a little way within the larger. Make a hole, about ½ inch in diameter, in the bottom of the smaller, to provide a vent for the mercurial vapors. Place the pieces of amalgam in the larger crucible, invert the smaller one into it, lute them, and fasten them firmly together with steel wire. Place the whole, as soon as the luting is dry, into a blast furnace, and in a short time the mercury will all have passed off in vapor, when the crucible may be set aside to cool, and the alloy will be found in a button at the bottom. As some portion of the tin in the alloy has been lost in the operation, the button should be remelted in a clean open crucible, with the addition of a little pure tin. This will now be ready to make again into amalgam as occasion requires.

3555. Ruhmkorf's Amalgamating Fluid. Dissolve by heat 2 parts by weight of mercury in 1 part aqua regia; when dissolved, add 10 parts hydrochloric acid. A worn-out zinc will be amalgamated in a few seconds by immersion in this fluid.

Gilding, Silvering, &c.

In this department we give processes for gilding and silvering wood, metals, paper, and glass; together with a number of receipts for coating various metals with other metallic deposits.

3557. Implements for Gilding on Wood. A sufficient quantity of leaf-gold, which is of two sorts—deep gold, and pale, or lemon gold. The former is the best; the latter very useful, and may occasionally be introduced for variety or effect.

A gilder's cushion; an oblong piece of wood, covered with rough calf-skin, stuffed with flannel several times doubled, with a border of parchment, about 4 inches deep at one end, to prevent the air blowing the leaves about when placed on the cushion.

A gilding knife, with a straight and very smooth edge, sharp enough to cut the gold, but not sufficiently so to cut the cushion. It must be *perfectly* clean, or the gold leaf will adhere to it.

Several camel's-hair pencils of assorted sizes; and tips, made of a few long camel's hairs put between two cards, in the same manner as hairs are put into tin cases for brushes, thus making a flat brush with a very few hairs.

A burnisher, which is a crooked piece of agate set in a long wooden handle.

3558. Burnished Gilding. This style of gilding is adapted for fine work, such as picture frames and other fancy furniture. We shall endeavor to give the necessary instructions, in the following receipts, to those who wish to undertake this kind of work, and with care and practice they may perform the operation successfully.

3559. To Make Size for Preparing Picture Frames and Other Wood Work for Gilding. To ½ pound parchment shavings, or cuttings of white leather, add 3 quarts water, and boil it in a proper vessel till reduced to nearly half the quantity; then take it off the fire, and strain it through a sieve. Be careful, in the boiling, to keep it well stirred, and do not let it burn.

3560. To Prepare or Whiten Picture Frames or Wood Work. First, with the above size alone, and boiling-hot, go over the frames in every part: then mix a sufficient quantity of whiting with size, to the consistency of thick cream, with which go over every part of the frame 6 or 7 times, carefully letting each coat dry before proceeding with the next; this will produce a white ground, nearly or quite $\frac{1}{16}$ inch in thickness. The size must not be too thick, and, when mixed with the whiting, should not be put on as hot as the first coat is by itself. It will be better to separate the dirty or coarse parts of the whiting by straining it through a sieve.

3561. To Clean and Polish Frames. When the prepared frames are quite dry, clean and polish them. To do this, wet a small piece at a time, and, with a smooth, fine piece of cloth, dipped in water, rub the part till all the inequalities are removed, and for those parts where the fingers will not enter, as the mouldings, &c., wind the wet cloth round a piece of wood, and by this means make the surface all equally smooth and even. Where there is carved work, &c., it will sometimes be necessary to bring the mouldings to their original sharpness by means of chisels, gouges, &c., as the preparation will be apt to fill up all the finer parts of the work, which must be thus restored. It is sometimes the practice, after polishing, to go over the work once with fine yellow or Roman ochre.

3562. To Make Gold Size for Frames. Grind fine sal-ammoniac well with a muller and stone; scrape into it a little beef-suet, and grind all well together; after which mix in with a pallet knife a small proportion of parchment size with a double proportion of water.

3563. Gold Size for Picture Frames. Grind a lump of tobacco pipe clay into a very stiff paste with thin size; add a small quantity of red ochre and fine black lead, ground very fine, and temper the whole with a small piece of tallow.

3564. To Prepare Picture Frames for Gilding. Take a small cup or pipkin, into which put as much gold size as you judge sufficient for the work in hand; add parchment size till it will just flow from the brush; when quite hot, pass over your work with a very soft brush, taking care not to put the first coat too thick; let it dry, and repeat it two or three times more, and, when quite dry, brush the whole with a stiff brush, to remove any roughness. The work is now ready for applying the gold. The parchment size should be of such a consistence, when cold, as the common jelly sold in the stores; for if too thick it will be apt to chip, and if too thin it will not have sufficient body.

3565. To Apply Gold Leaf to Picture Frames and Other Wood Work. This is the most difficult part of the operation, and requires some practice; but, with a little caution and attention, it may be easily performed. Turn the gold out of the book onto the cushion, a leaf at a time; then, passing the gilding-knife under a leaf, bring it into a convenient part of the cushion for cutting it into the size of the pieces required; breathe gently on the centre of the leaf, and it will lay flat on the cushion; then cut it to the proper size by sawing it gently with the knife till divided. Place the work in a position nearly horizontal, and, with a long-haired camel's-hair pencil dipped in water (or with a small quantity of brandy in the water), go over as much of it as the piece of gold is to cover; then take up the gold from the cushion with the tip; drawing it over the forehead or cheek will damp it sufficiently to adhere to the gold, which must then carefully be transferred to its place on the work, and, gently breathing on it, it will adhere; but take care that the part to which it is applied is sufficiently wet; indeed, it must be floating, or the gold will be apt to crack. Proceed in this manner by a little at a time, and do not attempt to cover too much at once. Be careful, in proceeding with the work, if any flaws or cracks appear, to take a corresponding piece of gold, and apply it immediately; sometimes, also, it will be necessary, when the gold does not appear to adhere sufficiently, to draw a pencil quite filled with water close to the edge of the gold, so that the water may run underneath it.

3566. To Burnish Gold. When the work is covered with gold, set it by to dry; it will be ready to burnish in about eight or ten hours; but this will depend on the warmth of the room or state of the air. When it is ready, those parts which are to be burnished must be dusted with a soft brush, and, wiping the burnisher with a piece of soft wash-leather (quite dry), begin to burnish about an inch or two in length at a time, taking care not to lean too hard, but with a gentle and quick motion apply the tool till it is equally bright all over.

3567. Matting, or Dead Gold. Those parts of the work which look dull from not being burnished, are now to be matted, that is, are to be made to look like dead gold; for if left in its natural state it will have a shining appearance, which must be thus rectified. Grind some vermilion, or yellow ochre, very fine, and mix a very small portion either with the parchment size or with the white of an egg, and with a very soft brush lay it even and smooth on the parts intended to look dull; if well done, it will add greatly to the beauty of the work. The work must be well cleared of superfluous gold, by means of a soft brush (a hat brush answers the purpose well), previous to burnishing or matting.

3568. To Finish Gilding. It is now only necessary to touch the parts in the hollows with a composition made by grinding vermilion, gamboge, and red lead, very fine, with oil of turpentine, and applying it carefully with a small brush in the parts required, and inserting suitable bits of gold leaf with a camel's-hair brush. Sometimes the finishing is done by means of shell-gold, which is the best method; it should be diluted with gum-arabic, and applied with a small brush.

3569. To Make Shell-Gold. Take any quantity of leaf-gold, and grind it, with a small portion of honey, to a fine powder; add a little gum-arabic and sugar candy, with a little water, and mix it well together; put it in a shell to dry until wanted.

3570. Oil Gilding is that which is designed for out-door work, to stand the weather and wash, and is performed with oil and varnish. Where the object is to give a high finish, paint the work with a color composed of the finest white lead and yellow ochre, in such proportions that the color shall be as near as possible to the color of the gold to be employed, mixed with oil (not boiled), and turpentine, till of the consistence of thin paint; this to be laid on evenly, and allowed to dry thoroughly, then repeat it for 5 or even more coats, till it is perceived that the grain or roughness of the object to be gilt is entirely hidden. When the last coat is dry it must be rubbed perfectly smooth, first with pumice stone, and finished with a piece of woolen cloth and finely pounded pumice; and lastly, with putty powder, till it is smooth as glass. It must then be varnished over with fine lac varnish several times, applying a slight degree of heat after each coat. This may be done by holding a hot iron near it till the varnish has flowed smooth and even over the surface. When the last coat of varnish is quite hard it must be polished; this is done by putting on a horse-hair glove, and rubbing the surface with this first, then with Tripoli, applied with a piece of wet woolen cloth; and lastly, by wet putty powder, first applied with woolen cloth, then with the bare hand, till it is as bright as glass. It must then be varnished over with a thin coat (the thinner the better) of gold size, and when sufficiently dry the gold is to be applied, beginning at the part that is dryest. When gilt, it is to be allowed to remain for two or three days, and then brushed over lightly with a camel's-hair brush to remove superfluous gold. It is next to be varnished with spirit varnish, applying heat as before, then varnished with copal varnish two or three times, allowing it to become perfectly hard between each coat; after the last coat of varnish it is finished by polishing, first with Tripoli, applied with a soft cloth and water, and then with the bare hand and a little oil, and wiped dry.

3571. Oil Size for Gilding. Grind calcined red ochre with the best and oldest drying oil, and mix with it a little oil of turpentine when used. When the work is to be gilded, first give it a coat of parchment size; then apply the above size where requisite, either in patterns or letters, and let it remain, till, by touching it with the finger, it feels just sticky; then apply the gold leaf, and dab it on with a piece of cotton; in about an hour wash off the superfluous gold with sponge and water, and when dry, varnish it with copal varnish.

3572. Water Size. Water size (for burnished gilding) is parchment size ground with yellow ochre.

3573. To Prevent the Adhesion of Gold Leaf. Painters and decorators will find the following plan a good one to simplify a most troublesome part of their work: A small piece of ball liquorice, dissolved in water, applied with a flat camel's-hair brush to the place intended to be left ungilt, will prevent the leaf adhering. The solution must be weak. Made thick and gummy, it is very useful to protect ornamental parts of work that is to be repainted.

3574. To Gild the Edges of Books and Paper. The gold applied to the edges of books, &c., is in the same state as for various ornamental purposes, namely, an extremely thin leaf. Before the case or cover of the book is quite finished, the volume is struck forcibly against the back, so as to make the fore-edge flat instead of concave. It is then placed in a press, with the exposed edge uppermost. The edge is scraped smooth with a piece of steel, and is coated with a mixture of red chalk and water. The gold is blown out from small books, and spread on a leather cushion, where it is cut to the proper size by a smooth-edged knife. A camel's-hair pencil is dipped into white of egg mixed with water, and with this the partially dry edge of the book is moistened; the gold is then taken up on a tip brush, and applied to the moistened edge, to which it instantly adheres. When all the three edges have been gilt in this way, and allowed to remain a very few minutes, take a burnisher formed of a very smooth piece of hard stone (usually bloodstone), and rub the gold very forcibly, which gives the gold a high degree of polish.

3575. Gilding on Glass. Mix powdered gold (*see No.* 2517) with thick gum-arabic and powdered borax. With this trace the design on the glass, and then bake it in a hot oven. Thus the gum is burnt, and the borax is vitrified, at the same time the gold is fixed on the glass.

Monograms and names may thus be gilded on glass or china.

3576. To Gild with Dutch Metal. The imitation of gold or silver leaf known as Dutch metal is much used for common purposes. The article to be gilded is prepared with a coating of oil size, on which the metal is laid. The sizing is not allowed to dry quite so long as for gold or silver leaf; the metal being laid on as soon as the size has set sufficiently not to smear. Metal is not handled with a gilding cushion and tip; but the books, with the metal in them, are cut into pieces of the requisite shape, with a pair of shears or scissors, and the metal leaf laid on the sizing direct from the portions of the book; after which it is pressed close by means of a roller covered with flannel, and finally brushed over the same as gold leaf, being careful to brush *with* and not *against* the overlap. White Dutch metal, nicely managed, and flowed over with shellac spirit varnish (colored with gamboge), makes a very good, cheap, and durable substitute for gold leaf.

3577. Grecian Gilding. Dissolve equal parts of sal-ammoniac and corrosive sublimate in nitric acid, and a solution of gold is to be made with the above mixture as a solvent; after slight concentration, the liquid is applied to the surface of silver, which immediately becomes black, but, on being heated, exhibits a rich gilded surface.

3578. Japanners' Gilding. The surface is covered with oil size thinned with spirits of turpentine, and gold in powder (*see No.* 2517) is gently dabbed on with a puff of wash-leather. This gives the appearance of frosted gold. A coating of varnish is next given, followed by a gentle heat in the stove.

3579. Leaf Gilding. This term is commonly applied to the gilding of paper, vellum, &c., by applying leaf gold to the surface previously prepared with a coating of gum water, size, or white of egg. It may be burnished with an agate.

3580. To Make Oil Gold Size. This is usually made from the sediment which collects at the bottom of the pot or dish in which painters wash their brushes, thoroughly ground and stained.

3581. Oil Gilding. The surface is prepared or primed with a coat of white lead in drying oil; then follow 2, 3, or 4 coats of calcined white lead ground in linseed oil and turpentine, with an interval of at least 24 hours between each coat, which must be carefully smoothed off with pumice-stone or shave grass. The gold size (*see No.* 3580) is next applied. When the gold size coat is sufficiently dry, the gold leaf is applied and pressed on with a wad or soft brush. After a few days for hardening, a coat of spirit varnish is applied, and the surface passed cautiously and evenly over a chafing dish of charcoal. For indoor work, it is finished off with a coat of pale oil varnish.

3582. To Gild Polished Metal. Polished silver, copper, brass, &c., may be gilded by the direct application of gold leaf to the surface heated to a bluish tint, pressing it on gently and carefully with the burnisher. This process is repeated until the proper thickness and tone is attained. Then it is polished with the burnisher and colored at the stove.

3583. Gold Tracing on Metal. Writing or any device in gold may be made on polished steel or iron, by tracing on the surface with a camel-hair pencil, using an ethereal solution of gold. The ether evaporating leaves a coating of gold, which may then be polished. (*See No.* 3585.)

3584. Water Gilding. This process involves several distinct operations, and can only be performed successfully by those who have learned the art practically.

3585. Ethereal Solution of Gold for Gilding on Steel. This process answers equally well for either gold or platina. Dissolve any quantity of gold or platina in nitro-muriatic acid (aqua regia), until no further effervescence is occasioned by the application of heat. (*See No.* 3588.) Evaporate the solution of gold or platina, thus formed, to dryness, in a gentle heat (it will then be freed from all excess of acid, which is essential), and redissolve the dry mass in as little water as possible; next take a separating funnel or pipette (*see No.* 3831), fill it about one-fourth with the liquid, and the other three parts must be filled with the very best sulphuric ether. *If this be rightly managed*, the two liquids will not mix. Then place the tube in a horizontal position, and gently turn it round with the finger and thumb. The ether will very soon be impregnated with the gold or platina, which may be known by its changing its color; replace it in a perpendicular position, and let it rest for 24 hours, having first stopped up the upper orifice with a cork. The liquid will then be divided into two parts—the darkest coloring being underneath. To separate them, take out the cork and let the dark liquid flow out; when it has disappeared, stop the tube immediately with the cork, and what remains in the tube is fit for use, and may be called gilding liquid. Let it be put into a bottle, and tightly corked. The muriate of gold or platina, formed by digesting these metals in nitro-muriatic acid, must be entirely free from all excess of acid, because it will otherwise act too forcibly on the steel, and cause the coating of gold to peel off. Pure gold must be employed; the ether must not be shaken with the muriate of gold, as is advised by some, for it will then be sure to contain acid; but if the two liquids be brought continually into contact by the motion described, the affinity between ether and gold is so strong as to overcome the obstacle of gravity, and it will hold the gold in solution. The ethereal solution may also be concentrated by gentle evaporation.

3586. To Gild Steel. Pour some of the ethereal solution of gold into a wine-glass, and dip into it the blade of a new penknife, lancet, or razor; withdraw the instrument, and allow the ether to evaporate; the blade will then be found covered with a beautiful coat of gold. The blade may be moistened with a clean rag, or a small piece of very dry sponge dipped into the ether, and the same effect will be produced. (*See No.* 3585.)

3587. Elkington's Patent, or Anglo-German Gilding. The articles, after being perfectly cleaned from scale or grease, and receiving a proper face, are to be suspended on wires, dipped into the gilding liquid (*see No.* 3588) boiling hot, and moved about therein, when, in from a few seconds to a minute, depending on the newness and strength of the liquid, the requisite coating of gold will be deposited on them. By a little practice the time to withdraw the articles is readily known; the duration of the immersion required to produce any given effect gradually increases as the liquid weakens by use. When properly gilded, the articles are withdrawn from the solution of gold, washed in clean water, and dried; after which they undergo the usual operation of coloring, &c. A dead appearance is produced by the application to the articles of a weak solution of nitrate of mercury previously to the immersion; or the deadening may be given by applying a solution of the nitrate to the gilded surface and then expelling the mercury by heat.

3588. Elkington's Patent Gilding Liquid. Fine gold, 5 ounces (troy); nitro-muriatic acid (aqua regia), 52 ounces (avoirdupois); dissolve by heat, and continue the heat until red or yellow vapors cease to be evolved; decant the clear liquid into a suitable vessel; add distilled water, 4 gallons; pure bicarbonate of potassa, 20 pounds; and boil for 2 hours. The nitro-muriatic acid is made with pure nitric acid (specific gravity 1.45), 21 ounces; pure muriatic acid (specific gravity 1.15), 17 ounces; and distilled water, 14 ounces.

3589. Gilding by Immersion. Dissolve teroxide or terchloride of gold in a solution of pyrophosphate of soda, and dip the article to be gilt in it.

3590. Gilding and Silvering by Amalgams. For these processes *see Nos.* 3532 *to* 3538.

3591. Gold Plating Powder. Wash thoroughly ¼ ounce chloride of gold; then add it to a solution of 2 ounces cyanide of potassium in a pint of clean rain water; shake well, and let it stand until the chloride is dissolved. Add 1 pound prepared Spanish whiting, expose to the air till dry, and then put away in a tight vessel for use.

3592. To Apply Gold Plating Powder. Make some gold plating powder into a paste with water, and rub it on the surface of the article with a piece of chamois skin or cotton flannel. The surface of the article should be thoroughly cleansed before applying the plating powder.

3593. Gilding Paste. Metallic surfaces are gilt by rubbing on the following mixture: Terchloride of gold, 36 parts; dissolve in pure water, 36 parts, and mix with a solution of cyanide of potassium, 60 parts, in pure water, 80 parts; shake well, and set by for 15 minutes, then filter. This liquid is thickened with a powder composed of prepared chalk, 100 parts; cream of tartar, 5 parts.

3594. Fire Gilding. This was extensively done before the discovery of the art of electroplating. Many a piece of beautiful workmanship has come down to us from ancient Rome and Greece, gilded, and probably in the same way as we do it now, under the name of fire-gilding. It requires more gold, the coating being thicker, and is therefore more expensive; but it will last longer, and is the more convenient way for gilding coins and small articles. Clean the silver piece, by means of a brush and a little ammonia water, until the surface is evenly bright and shows no tarnish. Take a small piece of gold and dissolve it in about 4 times its volume of metallic mercury, which will in a short time be accomplished and an amalgam formed. (*See Nos.* 3533 *and* 3534.) Put a little of this amalgam on a piece of dry cloth, and rub the silver piece with it on all sides; then place it on a clean stone in a furnace, and heat to the beginning of redness. After cooling it must be cleaned again with a brush and a little cream of tartar, when it will be found beautifully and lastingly gilded.

3595. To Remove the Gilding from Old China. The following method is recommended for removing the remains of gilding from old china: Take soft water, 8 parts by measure; nitric acid, 8 parts; common salt, 4 parts; sal-ammoniac, 1 part. Let it boil, put the china into it, and rub with a stiff brush.

3596. Wernicke's Method of Gilding Glass. The following are the ingredients required: 1st. Solution of gold. Pure gold, free from silver, is dissolved in aqua regia, the solution evaporated, and the residue taken up with water, so that 120 cubic centimeters (1 gill) contain 1 gramme (15.4 grains) of gold. 2d. Solution of sodic hydrate (which need not be absolutely pure) of 1.06 specific gravity. 3d. Reducing liquid. 50 grammes ($771\frac{1}{2}$ grains) sulphuric acid (monohydrate), 40 grammes (617 grains) alcohol, 35 grammes (539 grains) water, and 50 grammes powdered manganic peroxide, are distilled into 50 grammes of water until the bulk of the latter is doubled—10 grammes (154 grains) cane-sugar, inverted by dissolving in 70 cubic centimeters ($\frac{7}{12}$ gill) water, and boiling with $\frac{1}{2}$ gramme, ($7\frac{1}{2}$ grains) nitric acid of specific gravity 1.34. The distilled liquid, the inverted sugar, and 100 cubic centimeters ($\frac{10}{12}$ gill) alcohol are mixed together, and the mixture diluted to 500 cubic centimeters ($1\frac{1}{16}$ pints). In using these solutions, 1 volume of the sodic hydrate solution is mixed with 4 volumes of the gold solution, and to this mixture is added from 1.35 to 1.30 volume of the reducing liquid. The object to be gilded is placed on the top of the solution, having the surface intended to be coated turned downwards. The temperature of the bath should be below 140° Fahr.

3597. Boettger's Method of Gilding Glass. Boettger has modified Wernicke's process for throwing down gold on glass as follows: He prepares the soda solution by dissolving 6 grammes ($92\frac{1}{2}$ grains) caustic soda in 100 cubic centimeters ($\frac{10}{12}$ gill) water; the reducing fluid, to be made when washed, by dissolving 2 grammes (31 grains) common starch-sugar (glucose) in 24 grammes (370 grains) distilled water, and adding 24 cubic centimeters ($\frac{1}{5}$ gill) alcohol of 80 per cent., 24 cubic centimeters aldehyde of .870 specific gravity: neutral solution of chloride of gold, 1 gramme (15.4 grains) of gold in 1,200 cubic centimeters ($2\frac{1}{2}$ pints) water. Four volumes of the gold solution are mixed in a suitable vessel with one volume soda solution and 1.16 volumes of the reducing liquid, and the liquid rapidly poured into the hollow glass globe to be plated. Five minutes is sufficient to insure the deposit of a thin film of gold, but it is better to allow more time. Flat plates of glass can be laid upon the surface of the liquid, as in the silvering process; the surfaces of the glass should be carefully cleaned with soda and alcohol, and not with acids. The greater part of the gold is thrown down in flocculi, and can be recovered for subsequent use—the amount deposited upon the glass being very small. The mirrors are to be well washed and dried in the air. Where the baths are heated, the deposition of gold takes place more rapidly, but not so fine; it is better to keep the temperature below 140° Fahr, and to allow the metal coating to form slowly.

3598. Upton's Gold Detergent. Quicklime, 1 ounce; sprinkle with a little hot water to slack it, then gradually add 1 pint boiling water, so as to form a milk; dissolve 2 ounces pearlash in $1\frac{1}{2}$ pints boiling water; mix the two solutions, cover up, agitate occasionally for an hour, allow it to settle, decant the clear, put it into flat half-pint bottles, and cork them down well. It is used to clean gilding, &c., either alone or diluted with water. It is applied with a soft sponge, and then washed off with clean water. It is essentially a weak solution of potassa, and may be extemporaneously prepared by diluting liquor of potassa with about 5 times its volume of water.

3599. Gruene's Method of Gilding and Silvering Silk. By a formula published by Gruene, for silvering or gilding silk, the silk is to be soaked with a 5 per cent. solution of iodide of potassium, and dried; then (in non-actinic light, *see No.* 3140), dipped in a 5 per cent. solution of nitrate of silver, containing a few drops of nitric acid, and well drained; next exposed for a few minutes to sunlight, and then dipped in a 2 per cent. solution of sulphate of iron. It immediately becomes gray, from reduction of metallic silver, and, after washing and drying, only requires burnishing in order to acquire the metallic lustre. By repeating this treatment, varied, however, by adding a little free iodine to the solution of iodide of potassium, the silver deposit becomes stronger. By laying the silvered silk in a very weak solution of chloride of gold, the silver becomes chloride, and gold is deposited; and by then removing the chloride of silver by a soution of hyposulphite of soda, washing, drying, and burnishing, the appearance of gilding is produced, if the deposit of metal be sufficiently thick. The purest chemicals must be used in all gilding processes, in order to secure satisfactory results.

3600. Silvering Powder. Employed for silver coating dial plates, statuettes, and other articles of copper, and covering the worn parts of plated goods, previously well cleaned, by friction. They are made into a paste with a little water, for use.

3601. To Make Silvering Powder. Rub together to a fine powder 20 grains fine silver dust (*see No.* 3217), 30 grains alum, 1 drachm common salt, and 3 drachms cream of tartar; 35 grains of nitrate of silver may be substituted for the silver dust. Or: Dissolve chloride of silver in a solution of hyposulphite of soda, and make into a paste with levigated burnt hartshorn or bone dust; dry and powder it. Or: mix 1 ounce silver dust, 4 ounces each of common salt and sal-ammoniac, and $\frac{1}{4}$ ounce corrosive sublimate. In using the last, copper utensils are previously boiled with tartar and alum, and rubbed with this paste, then made red-hot, afterwards polished. Lastly: A good silvering powder may be made as follows: dissolve chloride of silver in a solution of hyposulphite of soda, and mix this with prepared hartshorn or other suitable powder.

3602. Novargent. This is said to consist of a solution of fresh precipitate chloride of silver in hyposulphite of soda (or, according to the Pharmaceutical Journal, of oxide of silver in cyanide of potassium), mixed with prepared chalk.

3603. Silvering Paste. Nitrate of silver, 1 part; cyanide of potassium (Liebig's), 3 parts; water sufficient to form a thick paste. Apply it with a rag. A bath for the same purpose is made by dissolving 100 parts of sulphite of soda, and 15 of nitrate of silver, in water, and dipping the article to be silvered into it.

3604. Silvering Solution. Prepare a solution of 1 part cyanide of potassium in 6 parts water; add it to a concentrated aqueous solution of nitrate of silver (free from acid) until the precipitate is redissolved. Mix this solution with fine chalk, and apply after previous cleaning of the objects.

3605. Non-poisonous Silvering Fluid. Nitrate of silver, 80 parts; dissolve in distilled water, 36 parts; add sal-ammoniac, 40 parts; hyposulphite of soda, 160 parts; and lastly, whiting, 160 parts. Apply in the usual way.

3606. Silver Plating Fluid. Dissolve 1 ounce crystals of nitrate of silver in 12 ounces soft water. Then dissolve in the water 2 ounces cyanide of potassium. Shake the whole together and let it stand till it becomes clear. Have ready some half-ounce phials, and fill them half full of Paris white, or fine whiting, and then fill up the bottles with the liquid, and it is ready for use. The whiting does not increase the coating power; it only helps to clean the articles, and to save the silver fluid by half filling the bottles. This is the preparation commonly vended by pedlers.

3607. Silver Solution for Plating Copper, Brass, and German Silver. Cut into small pieces a twenty-five cent piece, and put it into an earthen vessel with $\frac{1}{2}$ ounce nitric acid. Put the vessel into warm water, uncovered, until it dissolves. Add $\frac{1}{2}$ gill of water and 1 tea-spoonful of fine salt, and let it settle. Drain off and repeat, adding water to the sediment until the acid taste is all out of the water. Add finally about 1 pint of water to the sediment, and 4 scruples cyanide of potassium. Put into the solution a piece of zinc about 2 inches long, 1 wide, and $\frac{1}{8}$ in thickness. After cleaning, immerse the article to be plated in the solution about half a minute, letting it rest on the zinc. Wipe off with a dry cloth and repeat once. Polish with buckskin. The thickness of plate can be increased by repeating.

3608. Silvering Hooks and Eyes. A patent has been granted in Bavaria, for the following method of silvering hooks and eyes made of iron ware. The articles are suspended in dilute sulphuric acid until the iron shows a clean bright surface. After rinsing in pure water, they are placed in a bath of a mixed solution of sulphate of zinc, sulphate of copper and cyanide of potassium, and there remain until they receive a bright coating of brass. Lastly, they are transferred to a bath of nitrate of silver, cyanide of potassium and sulphate of soda, in which they quickly receive a coating of silver.

3609. To Plate Common Copper Buttons. Mix 2 ounces chloride of silver, 1 ounce corrosive sublimate, 3 pounds table salt, and 3 pounds sulphate of zinc, with water, into a paste. The buttons are cleaned, smeared over with the mixture, and exposed to a moderate degree of heat, which is afterwards raised nearly to redness, to expel the mercury which has united with the silver from the corrosive sublimate. The silvered surface is then cleaned and burnished.

3610. Simple Process for Silvering. This is an improved process for silvering copper, brass, and other alloys, by means of a solution of silver in cyanide of potassium; the difference from the usual method consists in the use of zinc-filings, with which the objects are coated; when the silvering solution is applied, an immediate deposition of a much more durable character taking place. The filings are easily removed by rinsing in water, and may be used repeatedly for the same purpose. Metallic iron may be coated with copper in the same manner, by substituting for the silver a solution of copper in cyanide; and over this copper deposit a coating of silver may be applied.

3611. Cold Silvering. Mix 1 part

chloride of silver with 3 parts pearlash, 1½ parts common salt, and 1 part whiting, and rub the mixture on the surface of brass or copper (previously well cleansed), by means of a piece of soft leather or a cork moistened with water and dipped into the powder. 1 part precipitated silver powder, mixed with 2 parts each cream of tartar and common salt, may also be used in the same way. When properly silvered, the metal should be well washed in hot water slightly alkalized, and then wiped dry.

3612. Spencer's Method of Silvering Wood. The first operation is to take strong alcohol or spirits of turpentine in a glass vessel, and add to it a piece of phosphorus (a common corked phial will answer the purpose); the vessel must now be placed in hot water for a few minutes, and occasionally shaken; by this means the alcohol will take about 3 per cent. of its bulk of phosphorus. Next procure a weak solution of nitrate of silver, place it in a flat dish or saucer; the face of the wood must now be dipped in this solution, and let it remain a few minutes to allow capillary attraction to draw it into the wood. This operation being performed, a small portion of the solution of phosphorus must be placed in a capsule or watch-glass, and this placed on a sand-bath, that it may gradually evaporate. The wood must now be held with its surface over the vapor, and an immediate change takes place; the nitrate of silver is decomposed, and gives place to metallic silver. When the material to be acted on is not very large, fasten it to the top of a bell-glass receiver with a bit of pitch or cement, and place this over the capsule on the sand-bath; the phosphorus vapor is by this means equally diffused, and not dissipated. A solution of phosphorus in sulphuric ether also answers; and a solution of gold (chloride) may be used. This elegant process, as applied to wood and those substances which may be wetted with the solution of nitrate of silver, answers perfectly; but it is obviously limited in its application to those substances which will absorb an aqueous solution.

3613. Silvering Glass. Two distinct methods are adopted for this purpose. The one falsely called silvering, consists of the application of a layer of an amalgam of tin, or similar alloy, to the surface of the glass (*see No.* 3614), the other is a coating of real silver, precipitated from a solution of that metal. (*See Nos.* 3615, *&c.*)

3614. To Silver Looking-Glasses. This is usually done by coating the glass with an amalgam. For this purpose a large, perfectly flat stone table is provided; upon it is evenly spread a sheet of tin foil without crack or flaw; this is covered uniformly to the depth of ⅛ inch with clean mercury. The plate of glass, perfectly cleansed from all grease and impurity, is floated on to the mercury carefully, so as to exclude all air bubbles. It is then pressed down by loading it with weights in order to press out all the mercury which remains fluid, which is received in a gutter around the stone. After about 24 hours it is raised gently upon its edge, and in a few weeks it is ready to frame. It is said to be desirable to have the lower end of the glass, from which the mercury was drained, at the bottom of the frame. To convex and concave mirrors the amalgamated foil is applied by means of accurately fitting plaster moulds. The interior of globes is silvered by introducing a liquid amalgam, and turning about the globe till every part is covered with it. (*See Nos.* 3538 *and* 3545.)

3615. To Silver Glass. An easy and economical process. Mix 90 parts by measure of a solution of Rochelle salts at 1.50 specific gravity, with 900 parts distilled water, and boil them in a flask; drop in carefully 20 parts of a solution of nitrate of silver specific gravity 1.18, and boil again. This solution can be bottled and kept for any length of time. Another fluid has to be prepared by adding ammonia to a solution of nitrate of silver until the precipitate is entirely dissolved; filtering and diluting 1 part of it with 100 parts of water. For use, put equal parts of the two preparations in a suitable vessel, clean the glass well (*see No.* 3621), and immerse it in the mixture until sufficiently coated. The coating of silver should be protected with a coat of lac varnish.

3616. Drayton's Process for Silvering Glass. Mr. Drayton mixes 1 ounce nitrate of silver, 3 ounces water, 1 ounce liquid ammonia, and 3 ounces spirit of wine, and filters the solution after it has stood 3 or 4 hours. To every ounce of the solution he adds ¼ ounce sugar (grape sugar if possible), dissolved in equal quantities of water and alcohol. The surface to be silvered is covered with this liquid at a temperature of 160° Fahr., maintained till the deposition of silver is complete. When quite dry, the coated surface is covered with mastic varnish. Other substances besides sugar occasion the deposition of silver from the ammoniacal solution; as oil of cassia, oil of cloves, and other essential oils, aldehyde, &c. Unger recommends a strong alcoholic solution of tannin. He had accidentally mixed in a dish a small quantity of a thick alcoholic solution of tannin with an equally small quantity of a strong solution of nitrate of silver; and in the course of a short time he found the dish coated with a thin, brilliant, and uniform layer of metallic silver. He directly repeated the experiment, and met with the same result again and again. He next proceeded to evaporate the liquid to dryness by placing the dish on the surface of warm sand. As soon as it was completely dry, the coating was found to be so fast on the porcelain that it required the point of a sharp penknife to scrape it off. He also succeeded in producing a brilliant metallic coating from a saturated solution of sulphate of copper by the same solution of tannin.

3617. Pettijean's Process of Silvering Glass. Two solutions are to be prepared. The *first* is composed of 26½ drachms nitrate of silver and 2 ounces aqua ammonia, dissolved in 1 pint of distilled water. After filtration this liquor is diluted with 16 times its volume of distilled water, and, drop by drop, a solution of 116½ grains of tartaric acid is added.

The *second* is prepared in the same manner, but with a double quantity of tartaric acid. As these solutions are rapidly reduced, prepare in the morning the liquors to be used during the day. Before silvering, the glass is perfectly cleaned, first with chalk and a fine cloth, then with a bung and a little of the first solution. It is then rubbed dry with a piece of chamois leather. (*See No.* 3621.) The glass, laid horizontally upon a table of cast iron, at a perfect level, is heated (by means of a cast iron water-bath beneath) to 113° Fahr., an India-rubber roller dipped in distilled water is next passed over its surface, and then its surface is covered with No. 1 solution. The deposit of silver commences in about 10 minutes, and is completed in about 15 minutes afterwards. The glass is then tilted up so as to allow the liquor to run off, and rinsed with water rather more than lukewarm to carry away the non-adherent powder. It is then restored to its horizontal position and covered with solution No. 2. In a quarter of an hour the deposit is completed. The next thing is to wash the plate as before, and dry it, after which it only remains to polish and burnish the film of silver deposited, in order to make it perfectly smooth, and give closeness to the grain. To cover a three-feet square of glass requires 5 pints of liquor. The deposit is, therefore, about 1½ drachms to every 9 square feet. To preserve the coating of silver from sulphuration and rubbing, it is covered with a paint made with 1 pound of lead pigment, 1½ ounces of drying oil, and 5½ ounces of spirits of turpentine. Liebig has produced the same result by depositing on the silver a coating of galvano-plastic copper, but the advantages resulting from the greatest solidity of the deposit scarcely compensate for the practical inconveniences of the process.

3618. To Silver Specula and Other Glass Surfaces. Make a solution of ammonio-nitrate of silver, of the strength of three grains to the ounce. Render it very slightly turbid by excess of nitrate of silver, and then filter it. Just before using, add to each ounce of the foregoing solution 2½ grains of Rochelle salts. Having scrupulously cleaned the glass intended to be silvered (*see No.* 3621), place it in a convenient vessel about one inch from the bottom, supported on three little cones of white wax. The glass plate may be suspended; but in that case there is more difficulty in avoiding vibration, the absence of which is essential to success. Expose to a northern light, or any other subdued light, and in about two hours the deposit of silver will be sufficiently thick. It must now be carefully removed, washed, and dried. When the surface next the glass is to be used as the reflector, the glass side should be cleaned by nitric acid if the state of its surface, after the silvering, so require; and the silvered side should receive a protecting coating of a good tough black varnish.

3619. Liebig's Process for Silvering Glass Mirrors. The process of silvering glass generally rests on the reduction of metallic silver from a solution by means of glucose or some other organic substance. By Liebig's method the deposit of silver is produced by the action of a mixture consisting of 50 parts by measure of a silver solution, and 10 parts of a reducing solution, this latter previously diluted with 250 to 300 parts water. The components of the silver solution are: 140 parts of a solution containing 10 per cent. of nitrate of silver; 100 parts of a solution of nitrate of ammonia (free from chlorine) of 1.115 specific gravity (or a solution of sulphate of ammonia of specific gravity 1.105–1.106;) lastly, 750 parts of caustic soda lye of specific gravity 1.050. In case sulphate of ammonia is used, its solution must be added to the silver solution, not as in the case of nitrate. The reducing solution consists of 1 part by measure of sugar liquor and 1 part of copper liquor.

The *sugar liquor* is prepared by dissolving 50 grammes (771⅝ grains) white sugar in water to a thin syrup, kept for 1 hour at a boiling heat with $3\frac{1}{10}$ grammes (48 grains) tartaric acid; the solution is then diluted to measure 500 cubic centimeters ($1\frac{1}{10}$ pints).

The *copper liquor* consists of a solution of $2\frac{857}{1000}$ grammes (44 grains) dry tartrate of copper in water, by the aid of a caustic soda solution added by drops until the blue salt is dissolved; the whole is then diluted with water to measure 500 cubic centimeters ($1\frac{1}{10}$ pints).

The glasses to be silvered, if for mirrors, are placed upright on their edge in the silvering tank and held together in pairs by clamps; when for optical purposes, they are held in a horizontal position, just touching the surface of the fluid. In cold seasons the temperature must be kept at 68° to 84° Fahr. The quantity of silver necessary for a square yard of surface is from 46 to 54 grains.

3620. Bird's Process for Silvering Mirrors or Specula. The mirror or speculum to be silvered is first cleaned (*see No.* 3621), and then suspended, face downwards, in a silver bath prepared thus: A large flat shallow vessel of glass or porcelain is provided, to contain the solution. 750 grains nitrate of silver are dissolved in 6 ounces distilled water, and to this is added pure liquid ammonia, drop by drop, until the precipitate which is thrown down is redissolved. 2 ounces caustic potash are dissolved in 50 ounces, by measure, of rain water; and 15 ounces of this solution are added to the ammoniacal solution, when a brown-black precipitate will be produced. Ammonia is again added, drop by drop, until this precipitate is just redissolved; and 29 ounces of distilled water are then added to the whole. To this mixture is again added, drop by drop, stirring with a glass rod, a strong solution of nitrate of silver, until a precipitate, which does not redissolve, begins to be formed. Previous to immersing the speculum, 1 part, by weight, of powdered milk sugar to 10 parts, by measure, of distilled water, must be prepared in a separate vessel, and filtered until a clear solution is obtained. Then, to 10 parts, by measure, of the silvering solution, must be added 1 part, by measure, of the milk sugar solution, and, finally, 50 ounces of the compound solution will be sufficient to silver a speculum 9 inches in diameter. To facilitate the suspending, a circular block of wood is very firmly cemented to the back of the speculum with marine glue or pitch, and three pins inserted at equal distances round the margin, to which strings may be fastened. On lowering it into the bath, care must be taken that no air bubbles intervene, that the speculum be not deeper in the liquid than half its thickness, and that a depth of 2 inches, at least, intervene between the face of the speculum and the bottom of the vessel. In 10 minutes after immersion a metallic film will be seen forming on the glass, and in an hour or two a compact silver coating will be laid over the whole surface. The speculum should remain in the bath for 4 hours, by which time the process is completed; it is then carefully removed, copiously washed with distilled water, and placed on its edge to dry. It is then ready for polishing. (*See No.* 3622.)

3621. To Clean the Surface of Glass for Silvering. As the success of the silvering process depends greatly on the glass surface being made chemically clean previous to immersion in the bath, the utmost pains must be taken to accomplish this object. The surface is first covered with thick whiting cream, free from grit, which, when dry, is rubbed off with the purest cotton wool. The surface is then wetted entirely with dilute nitric acid, and afterwards thoroughly washed with distilled water poured over it; and, last of all, the piece of coated glass is suspended in a flat vessel containing alcohol, where it remains until the bath is ready to receive it.

3622. To Polish a Silvered Surface on Glass. To accomplish this, rub the surface gently, first with a clean pad of fine cotton wool, and afterwards with a similar pad covered over with cotton velvet, which has been charged with fine rouge. The surface will, under this treatment, acquire a polish of intense brilliancy, quite free from any scratches.

3623. To Silver Glass for the Reflectors of Telescopes. The solutions employed are four in number, and they require some care in their first preparation; but once made they are always ready, and can be used with great rapidity and certainty for depositing a lustrous, mirror-like surface of silver on a piece of glass of any desired shape or curvature:—

Solution No. 1 is prepared by dissolving 1 part, by weight, of nitrate of silver, in 10 parts of distilled water.

Solution No. 2 consists of an aqueous solution of pure ammonia, having a density of 13.3° Baumé.

Solution No. 3 consists of 4 parts of pure caustic soda in 100 of distilled water.

Solution No. 4 is made by dissolving 12¼ parts of the best white loaf sugar in 100 parts distilled water. To this add 1 part, by measure, of nitric acid, boil for 20 minutes, in order to invert or alter the molecular arrangement of the particles of the sugar, and then add water to increase the volume to 500 parts by measure, and finally add 50 parts alcohol.

These solutions will remain unchanged for a long time. When required for use, prepare a silvering liquid by pouring into a flask 12 parts, by measure, of the silver solution, No. 1; 8 parts, by measure, of the ammoniacal solution, No. 2; then 20 parts of the soda solution, No. 3; and, lastly, add 60 parts of distilled water, in order to make up the volume to 100. If the proportions have been properly observed, the liquid so prepared will be perfectly clear, but will be rendered turbid by the smallest addition of nitrate of silver solution. It must be allowed to remain without disturbance for 24 hours, to permit the floating particles to settle. The clear liquid decanted from the sediment will then be ready for use. The surface of the glass which has to be silvered must be well cleaned with a tuft of cotton and a few drops of nitric acid, and then washed with distilled water. (*See No.* 3621.) Drain it, and support it on the surface of the silvering bath, which is composed of the above described silvering liquid, with the addition of $\frac{1}{12}$ or $\frac{1}{15}$ its volume of the sugar solution, No. 4. The surface to be silvered, should, by preference, be at the upper part of the liquid, so that the silver may be deposited on it from below upward. There are two advantages in this—first, the deposit is finer and more even; and, second, there is no danger of floating particles of dust settling on the surface. It is, however, scarcely necessary to say that silver will be deposited upon every part of the glass which is under the surface of the liquid, as well as upon the sides and bottom of the vessel; so that, as a matter of economy, as little as possible of the back of the glass should be exposed to the action of the liquid. The action seems to be more rapid in the light than in darkness. Under the influence of diffused light the liquid becomes yellow, then brown, and in a few minutes the whole of the exposed surface of the glass will be covered with a fine deposit of silver. In about a quarter of an hour the thickness of the metallic coating will be sufficient to bear the subsequent operations without injury; it must then be washed with plenty of water, and rested by one corner on several thicknesses of blotting-paper to dry spontaneously. The surface will now be covered with a thin whitish veil, which may be readily removed by gentle friction with chamois leather; it may afterwards be polished with jewelers' rouge, when a perfectly brilliant surface will be produced. (*See No.* 3622.)

3624. To Repair the Silvering of Looking-Glasses. The repairing of the silvering on the backs of looking-glasses has hitherto been considered a very difficult operation. A new and very simple method, however, has been described before the Polytechnic Society of Leipsic. It is as follows: Clean the bare portion of the glass by rubbing it gently with fine cotton, taking care to remove any trace of dust and grease. If this cleaning be not done very carefully, defects will appear around the place repaired. With the point of your knife cut upon the back of another looking-glass around a portion of the silvering of the required form, but a little larger. Upon it place a small drop of mercury; a drop the size of a pin's head will be sufficient for a surface equal to the size of the nail. The mercury spreads immediately, penetrates the amalgam to where it was cut off with the knife, and the required piece may now be lifted and removed to the place to be repaired. This is the most difficult part of the operation. Then press lightly the renewed portion with cotton; it hardens almost immediately, and the glass presents the same appearance as a new one.

3625. To Repair a Damaged Mirror. Pour upon a sheet of tin foil about 3 drachms of quicksilver to the square foot of foil. Rub smartly with a piece of buckskin until the foil becomes brilliant. Lay the glass upon a flat table, face downwards; place the foil upon the damaged portion of the glass; lay a sheet of paper over the foil, and place upon it a block of wood or a piece of marble with a perfectly flat surface; put upon it sufficient weight to press it down tight; let it remain in this position a few hours. The foil will adhere to the glass.

3626. Process for Silvering Animal, Vegetable, or Mineral Substances. This process is founded upon the electro-chemical action exercised by certain liquors in which the objects to be silvered are plunged. The method of preparing these liquors is as follows:

Liquor No. 1.—Take 2 parts by weight of caustic lime, 5 of sugar of milk or grape sugar, 2 of gallic acid, and make of them a mixture in 650 parts of distilled water; filter, protect from the air as much as possible, and put in a closely stoppered bottle until the moment of using.

Liquor No. 2.—Dissolve 20 parts nitrate of silver in 20 parts solution of ammonia, and add to this solution 650 parts distilled water. When it is intended to operate, the two preceding liquors are mixed in equal quantities, and, after having been well agitated, filtered. As the solution of ammonia of commerce has not always the same degree of concentration, it would be better, perhaps, to dissolve the nitrate of silver destined for the liquor No. 2, first in distilled water, then mix the solution with liquor No. 1, and then add ammonia in quantity only just sufficient to entirely clear the mixture. The deposition of silver can be accelerated by the employment of heat; in this case, the temperature depends upon the nature of the objects to be submitted to the operation. The method of employing the above liquors in silvering the surfaces of different materials is given in the following six receipts:

3627. To Silver Silk, Woolen, Cotton, Etc. When it is intended to silver silk, woolen, cotton, etc., commence by washing the substance clean; this done, immerse it for a moment in the saturated solution of gallic acid; then withdraw it to plunge it for a second in another solution composed of 20 parts nitrate of silver to 1000 parts distilled water. These alternate immersions are continued, until the substance from being dark becomes of a brilliant tint; after that it is plunged in a bath composed of a mixture of the two liquors, Nos. 1 and 2. (*See No.* 3626.) When it is completely silvered, it is withdrawn and boiled in a solution of salt of tartar (carbonate of potassa) in water, and there remains nothing more to be done but a last washing and drying.

3628. To Silver Bone, Horn, Paper, Etc. Bone, horn, wood, paper, etc., are silvered in the same way (*see No.* 3627) with this difference, however, that, in the place of the alternate immersions above indicated, the objects to be silvered are operated upon with a brush or pencil dipped alternately in the gallic acid solution and in that of nitrate of silver. The silvered surfaces are then washed with distilled water, dried by free air and heat.

3629. To Silver Leather. For leather *tanned with sumach*, in the place of nitrate of silver (*see No.* 3627) the chloride mixed with a few drops of rosemary oil may be employed with advantage. The silvered surface is then washed and dried as directed in last receipt.

3630. To Silver Stucco and Pottery. Stucco and pottery may be silvered by the same process as No. 3628, but before being submitted to the operation they should be covered with a coat of stearine or varnish.

3631. To Silver Glass, Crystal, or Porcelain. To silver glass, crystal, or porcelain, commence by washing thoroughly (*see No.* 3621) the object with distilled water, and with alcohol, and then operate as has been said with the mixture. (*See No.* 3626.) Objects with a plane surface should be placed in a horizontal position, and the liquor poured upon them. (*See Nos.* 3618, *&c.*) When mirrors are to be silvered, the plates of glass may be disposed in a vertical position; place them two and two face against face, in troughs of gutta percha, taking care to prevent all contact with the sides; then fill with the liquid. Precipitation of silver commences in a quarter of an hour, and at the end of a few hours the operation is finished. When dry, coat the silvered surface with varnish.

3632. To Silver the Metals. Commence by cleansing them with nitric acid; rub them afterwards with a mixture of cyanide of potassium and powdered silver; then, after washing with water, they are plunged alternately into the liquors Nos. 1 and 2 (*see No.* 3626), until they appear sufficiently silvered. If working with iron, it should be first immersed in a solution of sulphate of copper. The process which has been described presents above all others the advantage of very solid results, and of employing chemical agents of low price.

3633. To Coat Copper Plates with Brass. Expose the plates, heated sufficiently, to the fumes of zinc. Zinc boils and is vaporized by heating it to a white heat.

3634. To Coat the Inside of Copper Vessels with Brass. Dissolve 1 part zinc amalgam (*see No.* 3539) in 2 parts muriatic acid; add 1 part argol (crude tartar), and add sufficient water to fill the vessel; then boil it in the vessel.

3635. To Deposit Copper upon Cast Iron. The pieces of cast iron are first placed in a bath made of 50 parts hydrochloric acid, specific gravity 1.105, and 1 part nitric acid; next, in a second bath, composed of 10 parts nitric acid, 10 parts of chloride of copper, dissolved in 80 parts of the same hydrochloric acid as just alluded to. The objects are rubbed with a woolen rag and a soft brush, next washed with water, and again immersed until the desired thickness of copper is deposited. When it is desired to give the appearance of bronze, the copper surface, is rubbed with a mixture of 4 parts sal-ammoniac and 1 part each oxalic and acetic acids dissolved in 30 parts water.

3636. Graeger's Process for Covering Iron and Steel with Copper without a Battery. The objects are first well cleaned, and then painted over with a solution of protochloride of tin, and immediately afterward with an ammoniacal solution of sulphate of copper. The layer of copper thus produced adheres so firmly to the iron or steel, that the different objects can be rubbed and polished with fine chalk without injuring the deposit. The *tin solution* is prepared with 1 part crystallized chloride of tin, 2 parts water, and 2 parts hydrochloric acid. The *copper solution*, with 1 part sulphate of copper, 16 parts water, adding ammonia sufficient to redissolve the precipitate first thrown down by it. Zinc and galvanized iron can be treated, according to Boettger, directly by the copper solution, without using the tin salt. The above process may be found useful by gilders, and for various ornamental purposes.

3637. Weil's Process for Coating Iron with Copper. This process yields a coating of copper of great brightness and strong cohesion. The object, whether of cast or wrought iron, is freed from rust by immersion for from 5 to 10 minutes in water containing 2 per cent. of muriatic acid, and subsequent scrubbing for ½ hour with a wire brush and sand, then washing in water until all traces of acid are removed. It is then covered with zinc wire in spiral turns of about 6 inches from each other, which also serves as a means of suspension. The bath consists of a solution of 8 parts caustic soda in 100 parts water, of which 11 quarts are mixed with 50 ounces Rochelle salts and 12½ ounces sulphate of copper, making a liquid of a density equal to 19° Baumé. It retains its activity as long as the copper is kept replaced, and deposition from it proceeds with great regularity. The material of the vessel is best when made of wood, lined with gutta-percha, and covered with a wooden lid. When the coating is of sufficient thickness, the object is removed from the bath, first washed with water slightly acidified with sulphuric acid, and then with pure water until the disappearance of all traces of acid; after this it passes into a drying room heated to 132° Fahr. The bronzing, when required, is obtained by a bath of sulphide of sodium, or by means of the same bath as above, somewhat modified, that is, by increasing the proportion of copper to a threefold, in which case the bath no longer deposits copper, but, to all appearances, bronze. By reducing the points of contact between the iron and wire, though retaining the spiral turns at uniform distances, the deposit gradually assumes a number of colors in the following series, viz.: orange, silver-white, pale yellow, golden yellow, carmine, green, brown, and dark bronze. As soon as the desired color is attained, the object is washed in warm water, and again dried at 132°. Between each subsequent change of color is an interval of about 5 minutes. The reaction is more decided when the alkaline reaction of the bath is stronger. For indoor work or ornaments the time of immersion may vary from 3 to 72 hours; for outdoor objects a much longer time would be necessary.

3638. To Tin Iron Pots and other Domestic Articles. The articles are cleaned with sand, and, if necessary, with acid, and put then in a bath, prepared with 1 ounce cream of tartar, 1 ounce tin salt (protochloride of tin), 10 quarts water. This bath must be kept at a temperature of 190° Fahr., in a stoneware or wooden tank. Bits of metallic zinc are put into and between the different pieces. When the coat of tin is considered thick enough, the articles are taken out of the fluid, washed with water, and dried.

3639. To Tin by the Moist Way. Make a solution of 1 part protochloride of tin in 10 parts water, to which add a solution of 2 parts of caustic soda in 20 parts water; the mixture becomes turbid, but this does not affect the tinning operation, which is effected by heating the objects to be tinned in this fluid, care being taken, at the same time, to place in the liquid a piece of perforated block tin plate, and to stir up the fluid during the tinning with a rod of zinc.

3640. To Tin Iron Without the Aid of Heat. To 105 quarts water are added 6½ pounds rye meal; this mixture is boiled for 30 minutes, and next filtered through cloth; to the clear but thickish liquid are added 233 pounds pyrophosphate of soda, 37½ pounds protochloride of tin in crystals (so-called tin salt), 147½ pounds neutral protochloride of tin, 3½ to 4 ounces sulphuric acid; this liquid is placed in well made wooden troughs, and serves more specially for the tinning of iron and steel wire (previously polished) for the use of carding machines. When, instead of the two salts of tin just named, cyanide of silver and cyanide of potassium are taken, the iron is perfectly silvered.

3641. To Cleanse Iron for Tinning. The metal must be cleansed by immersion in an acid solution; for new metal, this solution should be sulphuric acid and water, but for old metal, muriatic acid and water; next scour with sand, and cleanse well with water.

3642. To Tin Iron. First cleanse as above, then heat the article just hot enough to melt the tin, rub the surface over with a piece of sal-ammoniac, and sprinkle some of the sal-ammoniac in powder over it; then apply the tin and wipe it over evenly with a piece of tow.

3643. Cold Tinning. Rub pure tin-foil and quicksilver together until the amalgam becomes soft and fusible, clean the surface to be tinned with spirits of salt (hydrochloric acid), and, while moist, rub the amalgam on, and then evaporate the quicksilver by heat.

3644. Stolba's Method of Tinning Copper, Brass, and Iron in the Cold, and without Apparatus. The object to be coated with tin must be entirely free from oxide or rust. It must be carefully cleaned, and care be taken that no grease spots are left; it makes no difference whether the object be cleaned mechanically or chemically. Two preparations are requisite for the purpose of tinning. *Zinc powder*—the best is that prepared artificially by melting zinc and pouring it into an iron mortar. (*See No.* 3312.) It can be easily pulverized immediately after solidification; it should be about as fine as writing sand. *A solution of protochloride of tin*, containing 5 to 10 per cent., to which as much pulverized cream of tartar must be added as will go on the point of a knife.

The object to be tinned is moistened with the tin solution, after which it is rubbed hard with the zinc powder. The tinning appears at once. The tin salt is decomposed by the zinc, metallic tin being deposited. When the object tinned is polished brass or copper, it appears as beautiful as if silvered, and retains its lustre for a long time. This method may be used in a laboratory to preserve iron, steel, and copper apparatus from rust; and would become of great importance if the tinning could be made as thick as in the dry way, but this has not as yet been accomplished.

3645. To Tin Copper Tubes. W. Wollweber recommends for still-worms copper tubes tinned inside in the following manner: To a solution of Rochelle salts a solution of salts of tin is added; a precipitate of stannous tartrate is formed, which is washed and then dissolved in caustic lye. The copper tube, which has first been rinsed with sulphuric acid and then washed, is then filled with the alkaline solution, warmed a little, and touched with a tin rod, which causes the deposition of a coat of metallic tin.

3646. To Tin a Worn Copper Kettle. A thick coating may be obtained by preparing a tinning solution of zinc dissolved in muriatic acid, making the solution as thick or heavily charged with zinc as possible, adding a little sal-ammoniac. Clean the inside of the kettle, place it in a charcoal fire until a piece of block tin placed inside melts, then rub the melted tin with some of the tinning solution, quickly on the copper surface, by means of a ball of oakum and a little powdered resin; the tin will readily adhere. Wrought-iron and steel may be tinned in the same manner.

3647. To Tin a Copper Vessel. Boil the copper vessel with a solution of stannate of potassa mixed with tin borings, or boil with tin filings and caustic alkali or cream of tartar. In a few minutes a layer of pure tin will be firmly attached.

3648. To Tin Cast Copper or Brass. Make a saturated solution of oxide of tin (*tin putty*), in potash lye; add to the solution some tin filings or shavings; make it as hot as possible; then introduce the brass or copper and it will be tinned in a few seconds.

3649. To Galvanize Iron. The difference between galvanized plates, so-called, and "sheet-tin," is, that the latter is sheet-iron covered with a thin coating of block-tin, while the former is sheet-iron covered with a thin coating of zinc. To effect the latter result, the iron plates are first immersed in a *cleansing bath* of equal parts of sulphuric or muriatic acid and water, used warm. (*See No.* 3266.) They are then scrubbed with emery or sand, to clean them thoroughly and detach all scales, if any are left; after which they are immersed in a *preparing bath* of equal parts of saturated solutions of chloride of zinc and chloride of ammonium, from which bath they are directly transferred to the fluid *metallic bath*, consisting of 20 chemical equivalents of zinc to 1 of mercury; or, by weight, 640 pounds of zinc to 100 of mercury, to which are added from 5 to 6 ounces of sodium. As soon as the iron has attained the temperature of this hot fluid bath, which is only 680° Fahr., it may be removed, and will then be found thoroughly coated with zinc. Care must be taken not to leave the plates too long immersed in this bath, as its affinity for iron is such that they may become dissolved. This is the case with thin plates of wrought-iron, which, even when ¼ inch thick, may be dissolved in a few seconds. It is safe, therefore, to let the bath previously act on some wrought-iron, so that it dissolves a portion of it, in order to satisfy its inconveniently great affinity for this metal.

3650. To Zinc or Galvanize Grey Iron Castings. Cleanse the articles in an ordinary chafing mill, which consists of a barrel revolving on its axis containing sand; when the sand is all removed, take them out and heat one by one, plunging, while hot, in a liquid composed as follows: 10 pounds hydrochloric acid, and sufficient sheet zinc to make a saturated solution. (*See No.* 3473.) In making this solution, when the evolution of gas has ceased, add muriate, or preferably sulphate of ammonia, 1 pound, and let it stand until dissolved. The castings should be so hot that when dipped into this solution, and instantly removed, they will immediately dry, leaving the surface crystallized like frost-work on a window pane. Next plunge them while hot, but perfectly dry, into a bath of melted zinc, previously skimming the oxide on the surface away, and throwing thereon a small amount of powdered sal-ammoniac. If the articles are very small, inclose them in a wrought-iron basket on a pole, and lower them into the metal. When this is done, shake off the superfluous metal, and cast them into a vessel of water to prevent them from adhering when the zinc solidifies.

3651. To Zinc Copper or Brass Vessels. Boil the vessel in a solution of chloride of zinc, adding a quantity of zinc turnings to the solution.

3652. Boettger's Process for Coating Copper and Brass with Zinc by a Wet Process. Place zinc in grains or powder in a non-metallic vessel, and cover the zinc with a concentrated solution of sal-ammoniac; warm to ebullition, and introduce into the mixture the objects of copper or of brass which it is desired to coat, after having properly cleansed them. After a few minutes, the object will be covered with a brilliant, firmly adhering deposit of zinc. (*See No.* 3312.)

3653. To Coat Copper with Zinc. To granulate the zinc, a clean surface of copper may be coated with zinc by placing the two metals in contact in a solution of caustic soda or potash. (*See Fig. I., No.* 3665.) In the cold the deposit of zinc takes place slowly, but at 100° it is effected rapidly.

3654. Purcher's Method of Coating Zinc with Iron. Dissolve 5 ounces pure sulphate of iron, and 3 ounces sal-ammoniac, in 5 pounds of boiling water, and immediately immerse the objects to be treated. After from 1 or 2 minutes the loose black deposit is removed by brushing it off with water. The principal effect of this operation is a perfect cleaning of the surface. The immersion in the hot iron solution is then repeated, with the difference that the objects, when taken out, are heated, without rinsing, over a pan of live coals as long as the ammoniacal vapors are evolved. When, after several immersions, the coating is considered thick enough, it is polished by brushing, and will ever afterward be a perfect protection against oxidation. It imparts a fine black lustre to the coated surfaces.

3655. Process for Covering Articles of Zinc with Copper or Brass by One Immersion. To give zinc a coat of copper or brass for the purpose of a subsequent silvering or gilding, the following solutions are used: For copper alone, a solution of sulphate of copper, saturated at the common temperature, is mixed with a solution of cyanide of potassium, adding as much of the latter as is necessary to redissolve the precipitate thrown down at first. The prussic acid disengaged during this operation must be carried off by a draught or flue. When the mixture is clear, $\frac{1}{10}$ or $\frac{1}{8}$ of its volume of water of ammonia is added, and then diluted with water to a density of 8° Baumé. For brass, sulphate of copper and sulphate of zinc are used in equal proportion, and prepared as before. 2 parts sulphate of zinc and 1 of sulphate of copper give a bright brass coating. Previous to their dipping, the articles of zinc are rubbed off thoroughly with finely-powdered pumice-stone and rinsed in water, after which they are placed in the bath and remain there for 24 hours. After that time they are again rinsed in water and simply wiped off. The copper or brass covering has a very bright look, as if polished, and adheres perfectly. The thickness of the coat may be increased afterwards by the aid of a battery.

3656. Dullo's Method of Platinizing Glass. This is recommended to prevent fusing of the thin end of a glass tube used for a blowpipe. In drawing out the end of the tube, leave the diameter slightly larger than is necessary; then roughen the narrow end with a file. Dip in a solution of bichloride of platinum, containing 5 per cent. of the metal; remove excess of the drop, and heat cautiously till the glass acquires a metallic appearance. Repeat this 4 or 5 times.

3657. Boettger's Method of Platinizing Glass. Pour rosemary oil upon the dry chloride of platinum in a porcelain dish, and knead it well until all parts are moistened; then rub this up with 5 times its weight of lavender oil, and leave the liquid a short time to clarify. The objects to be platinized are to be thinly coated with the above preparation and afterwards heated for a few minutes in a muffle or over a Bunsen burner.

3658. Platinizing Copper, Yellow Metal, and Brass. In order to obtain a platinizing fluid capable of platinizing copper, yellow metal, and brass, add to a moderately concentrated solution of chloride of platinum, finely powdered carbonate of soda, until effervescence ceases; next some glucose, and afterwards just so much common salt as will cause a whitish-colored precipitate. When it is desired to apply this mixture for platinizing, the objects to be treated are placed in a vessel made of zinc and perforated with holes; the vessel is then placed, with its contents, for a few seconds in the mixture thus described, which, just previous to using, should be heated to 140° Fahr. On being removed from the zinc vessel, the objects are to be washed with water and dried in sawdust.

3659. Stolba's Method of Nickel Plating. Into the plating vessel—which may be of porcelain, but preferably of copper—is placed a concentrated solution of chloride of zinc, which is then diluted with from 1 to 2 volumes of water, and heated to boiling. If any precipitate separates, it is to be redissolved by adding a few drops of hydrochloric acid. As much powdered zinc as can be taken on the point of a knife is thrown in, by which the vessel becomes covered internally with a coating of zinc. The nickel salt—for which purpose either the chloride or sulphate may be used—is then added until the liquid is distinctly green; and the articles to be plated, previously thoroughly cleaned, are introduced, together with some zinc fragments. The boiling is continued for 15 minutes, when the coating of nickel is completed, and the process is finished. The articles are well washed with water and cleaned with chalk. If a thicker coating be desired, the operation may be repeated. Professor Stolba found that copper vessels thus plated were scarcely tarnished after several months' use in the laboratory.

Electrotyping.

This is a process for depositing a coating of metal on objects, metallic or otherwise, by the agency of a current of galvanic electricity. Before entering into any description of the methods employed, it will be necessary to give some indispensable preliminary directions, in order that the whole matter may be more clearly understood. The matter is mainly derived from the 4th edition of Napier's Manual of Electro-Metallurgy.

3661. Solution of Copper for Electrotyping. Crush fine sulphate of copper in crystals, and expose to the air for some time. This oxidizes any iron that may be present. Stir the sulphate of copper into pure cold water, until the water will dissolve no more; then let it settle, and decant the clear solution; add to it about one-fourth its quantity of water, and it is ready for use.

3662. To Amalgamate Zinc. Immerse a plate or strip of zinc of the required size in diluted sulphuric acid, for a few moments; then rub quicksilver over the surface. Whenever the surface of the amalgamated zinc employed in a battery begins to blacken and lose its quicksilver coating, the zinc must be taken out of the acid cell and amalgamated again.

3663. To Keep the Zinc Plates of a Smee's Battery Constantly Amalgamated. The trouble of renewing the coating of amalgam on the zinc plates may be obviated by a very simple contrivance. Cover the bottom of the cell with quicksilver, and let the zinc plates be long enough to dip into it. The silver plate must be a little shorter than the zinc plates, so that it will not touch the mercury. By this arrangement the zinc plates draw up the mercury as fast as it is worn off by the action of the acid.

3664. Decomposing Cell. This is a vessel of suitable shape and dimensions, containing the plating or electrotyping solution; and is usually furnished with appliances over it for suspending and sustaining in their proper position the *negative electrodes* or articles to receive the metallic coating, and their corresponding *positive electrodes*, or plates of metal, which serve to complete the electric circuit, and whose decomposition serves to keep up the strength of the solution. The positive electrode must always be of the same metal as that which the solution contains.

3665. The Principles of the Galvanic Battery Explained. If a piece of ordinary metallic zinc be put into dilute sulphuric acid, it is speedily acted upon by the acid, and hydrogen gas is at the same time evolved from its surface. If the zinc be taken out, and a little mercury be rubbed over its surface, an amalgamation takes place between the two metals, and the plate becomes of a beautiful bright silver appearance. If the zinc thus amalgamated be again put into the dilute acid, there is no action, for the mercury retains the zinc with sufficient force to protect it from the acid. If a piece of copper be immersed along with the zinc, and the two metals be made to touch each other, a particular influence is induced among the three elements, zinc, copper, and acid; and the acid again acts upon the zinc as if no mercury was upon it, but the hydrogen is now seen to escape from the surface of the copper; this action will go on as long as the two metals are kept in contact. Or if, instead of causing the two metals to touch, a wire be attached to each, and their opposite ends are placed in a little dilute acid in another vessel, the same action will take place between the zinc and copper as when they were in contact; but in this instance, the ends of the two wires which dip into the vessel containing acid will undergo a change; the one attached to the zinc will give off a quantity of hydrogen gas, while the one attached to the copper, supposing it to be also copper, will rapidly dissolve.

Figure 1. Represents the zinc and copper, placed in dilute sulphuric acid, brought into contact; in this experiment, gas will be seen escaping from the copper.

Fig. 1. *Fig.* 2. *Fig.* 3.

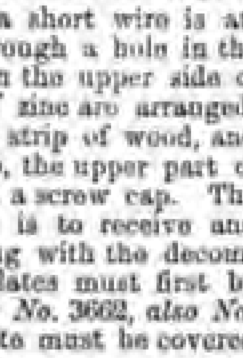
Figure 2. Zinc and copper, placed in dilute acid, and wires attached, which, when connected, will exhibit the same effects as in the first case.

Figure 3. Shows the wires connected by means of a liquid, such as acid and water, sulphate of copper, etc., contained in a wine-glass.

The copper and zinc, C and Z, with the acid in the first vessel, figure 3, constitute a battery of one pair. The wine-glass in which the wires are placed, is termed the decomposing cell (*see No.* 3664), and is the receptacle or vessel in which the process of electroplating is effected. The above description will give a tolerably clear idea of the principles of a simple galvanic battery. Different kinds of batteries are only different modifications or applications of the same principles, and have each their special excellence; but for electroplating, Smee's battery is the one usually adopted.

3666. To Construct a Cheap Galvanic Battery. Take a gallon stone jar, and place a sheet-zinc cylinder therein, and inside that a porous cup (a porous flower-pot with a cork fitted in the hole will answer after a fashion). Inside the porous cup place a piece of sheet copper. Use a solution of common salt next the zinc, and a solution of sulphate of copper next the copper in the porous cup, if a strong current be desired. The liquids inside and outside the porous cup should stand at the same level. Dilute sulphuric acid (1 part acid to 10 water) makes a very constant, but weaker current.

3667. Description of a Smee's Battery. This apparatus consists of a vessel containing a mixture of about 15 or 20 (Morfit gives only 7) parts water to 1 part sulphuric acid, provided with a strip of baked and varnished wood, long enough to stand across the edge of the vessel, and grooved lengthways underneath, to receive the edge of a silver plate, to which a short wire is attached and connected through a hole in the wood with a screw cap on the upper side of the wood. Two plates of zinc are arranged, one on each side of the strip of wood, and secured by a screw clamp, the upper part of which is also fitted with a screw cap. The object of the screw caps is to receive and secure the wires connecting with the decomposing cell. The zinc plates must first be coated with amalgam (*see No.* 3662, *also No.* 3663); and the silver plate must be covered with a coating of platina. (*See No.* 3670.) The arrangement of the parts will be seen in the cut. When two or more cells are used in combination, forming a compound battery, the silver plate of the first cell is connected by a wire with the zinc plates of the second; the silver plate of the second cell is connected with the zinc of the third cell; the silver of the third with the zinc of the fourth, and so on through any number of cells. The two wires connecting the battery with the decomposing trough are attached, one to the zinc plates of the *first* cell, and the other to the silver plate of the *last* cell. In fact, the zinc pole of the first, and silver pole of the last cell, really constitute the battery, the intermediate cells each furnishing an additional quota, as it were, of intensity, to the galvanic current.



The wire connected with the zinc (or *positive*) plates is called the *negative* pole or *cathode*; and the wire connected to the silver (or *negative*) plate is called the *positive* pole or *anode*. The material used for connecting wires is usually copper, and should be clean and bright, and in order to insure perfection of contact, the ends of the wire may be amalgamated by dipping, first in a solution of nitrate of mercury, and then in metallic mercury.

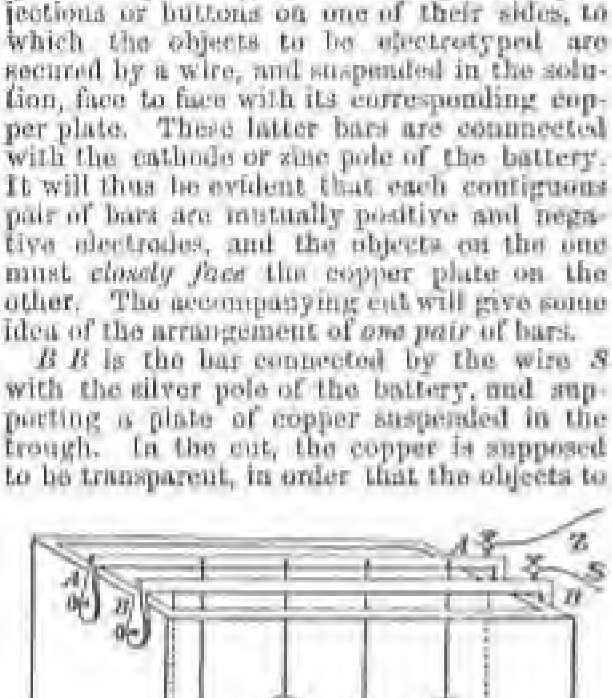
3668. Improved Liquid for the Galvanic Battery. Mr. Victor Barjon's new battery liquid is made by mixing a solution of bichromate of potash with a little lime, and with sulphuric acid. He puts 2 pounds bichromate of potash into a gallon of boiling water, and lets the solution cool down to 68°, and adds 2 ounces of lime. After stirring, he adds sulphuric acid until the gravity reaches 35° Baumé. Then, having stirred the whole, he lets it stand for 24 hours, when it is ready for use.

3669. Electrotyping by the Single Cell Process. This is an adaptation of Daniell's cell to the purposes of electrotyping, and dispenses with any separate decomposing cell; in fact it is a galvanic battery and a decomposing cell combined in one, and is useful, for small objects, from its simplicity. About ¾ fill a large jar (a preserve jar without any neck is best), with a solution of sulphate of copper (*see No.* 3661); insert in this a small tubular porous vessel of about the same height as the jar (these porous tubes can be found at any store where chemical apparatus is sold), and pour into it a mixture of 21 parts water and 1 part sulphuric acid, until the diluted acid in the porous tube stands at the same level as the sulphate of copper solution outside it. To one end of a piece of copper wire fasten a strip of amalgamated zinc (*see No.* 3662), which is to be inserted in the porous tube; to the other end of the wire attach the object to be electrotyped, properly prepared (*see No.* 3689), and place it in the copper solution, with its face parallel to the zinc plate, and about ½ an inch from the side of the porous tube. In about 24 hours the deposit of copper will be of about the thickness of a card, and may be taken off. When not in use, the zinc should be taken out, washed and dried; and when in use must on no account touch the bottom or any other part of the porous tube. It is a good plan to give the wire one twist round a stick of wood, laid across the top of the tube, so as to suspend and support the zinc. A few crystals of sulphate of copper, enclosed in a piece of lawn or net, should be hung from the edge of the vessel just below the surface of the copper solution, to replace the copper that deposits on the object being electrotyped, and prevent the solution from becoming weaker.

3670. To Coat Silver with Platina. This is effected by the one cell process, substituting for the sulphate of copper solution, water acidulated with sulphuric acid, and containing a little chloride of platinum. The silver is first roughened on the surface by applying strong nitric acid, and washed; it is then attached to the end of the wire leading from the zinc plate in the porous cell, and immersed in the platinum solution exactly as if it were a medal to be electrotyped, until the surface is covered with a dark and granular deposit.

3671. Electrotyping with a Battery. For this purpose a Smee's battery (*see No.* 3667) is usually employed, in connection with a decomposing cell. (*See No.* 3664.) As the method for electrotyping, or coating with copper, is substantially the same as for other metals, a description of the first will suffice. The decomposing cell being charged with a solution of sulphate of copper (*see No.* 3661), the object, duly prepared (*see No.* 3689), to be electrotyped, is properly secured in position, and connected with the cathode or wire leading from the zinc plates of the battery. To the anode or wire leading from the silver plate, a positive electrode, consisting of a piece of the same metal as the solution contains (in this case, copper), is attached, and immersed in the solution, face to face with the object to be electrotyped; as the copper from the solution is precipitated on the object, the piece of copper is dissolved, and thus keeps up the strength of the solution. Any number of objects may be electrotyped in the same decomposing cell, provided that each is connected with the zinc pole of the battery, and hangs facing a positive electrode. The usual arrangement for this purpose consists of a water-tight trough of suitable size and shape (usually oblong), to contain the copper or other metallic solution, and is provided with metal bars, long enough to reach the length of the trough and rest on the upper edge at each end; the bars rest on dry varnished blocks of wood, and are laid parallel to each other at a distance of 3 or more inches apart, according as the space between them is required. Plates of copper of nearly the same length as the trough are suspended from the bars, and submerged in the solution parallel with them. These bars, and consequently the copper plates (which constitute continuous positive electrodes) are connected with copper wire or ribbons to the anode, or silver pole of the battery. Alternately between these bars, other bars are placed, exactly similarly arranged, but having small projections or buttons on one of their sides, to which the objects to be electrotyped are secured by a wire, and suspended in the solution, face to face with its corresponding copper plate. These latter bars are connected with the cathode or zinc pole of the battery. It will thus be evident that each contiguous pair of bars are mutually positive and negative electrodes, and the objects on the one must *closely face* the copper plate on the other. The accompanying cut will give some idea of the arrangement of *one pair* of bars.

B B is the bar connected by the wire *S* with the silver pole of the battery, and supporting a plate of copper suspended in the trough. In the cut, the copper is supposed to be transparent, in order that the objects to



be electrotyped, suspended from the bar *A A*, may be visible; they are supposed to be *behind* and *closely facing* the copper plate. The bar *A A* is connected by the wire *Z* to the zinc pole of the battery.

3672. To Obtain a Copper Mould of a Coin. A fine copper wire must be put round the edge of the coin and fastened by twisting. Then cover the back part, and the wire, upon which the deposit is not required, with bees' wax or tallow, or, what is better, imbed the back of the coin in gutta percha. Have the fore part or face well cleaned, and the surface moistened with sweet oil, by a camel's-hair pencil, and then cleaned off by a silk cloth, till the surface appears dry; or, instead of oil, the surface may be brushed over with black lead, which will impart to it a bronze appearance. The use of the oil or black lead is to prevent the deposit adhering to the face of the coin. The coin is now ready to be subjected to the single cell process (*see No.* 3669), by which means a perfect counterpart or mould of the coin is obtained. This mould may next be treated exactly as described for obtaining it from the original coin, and the deposit from it will be a fac-simile of one side of the coin. With care, any number of duplicates may be taken from this mould, if it be properly coated.

3673. Coating for Copper Moulds. Take a gill of rectified spirits of turpentine, and add to it about the size of an ordinary pea of bees' wax. When this is dissolved, wet over the surface of the mould with it, and then allow it to dry: the mould is then ready to put into the solution. Medals taken from moulds so prepared retain their beautifully bright color for a long time. But when fine line engravings are to be coated, the little wax dissolved in the turpentine may be objectionable; so also is black lead, for both have a tendency to fill up the fine lines. In this case, let the turpentine wash be wiped off with a silk handkerchief, instead of drying it; but for ordinary medals this objection will scarcely apply.

3674. Preparation of Wax for Taking Moulds. Whether the bees' wax have stearine in it or not, it is best to prepare it in the following manner: Put some common virgin wax into an earthenware pot or pipkin, and place it over a slow fire; and when it is all melted, stir into it a little white lead (flake white), or black lead (plumbago), say about 1 ounce white lead to the pound of wax; this mixture tends to prevent the mould from cracking in the cooling, and from floating in the solution; the mixture should be re-melted two or three times before using it for the first time. Resin has been recommended as a mixture with wax; mixtures of which, in various proportions, have been used with success; but when often used, decomposition or some change takes place, which makes the mixture granular and flexible, rendering it less useful for taking moulds. When resin is used, the mixture, when first melted, should be boiled, or nearly so, and kept at that heat until effervescence ceases; it is then to be poured out upon a flat plate to cool, after which it may be used as described.

3675. To Take Moulds in Wax. The medal to be copied must be brushed over with a little sweet oil: a soft brush, called a painter's sash tool, suits this purpose well: care must be taken to brush the oil well into all parts of the medal, after which the superfluous oil must be wiped off with a piece of cotton or cotton wool. If the medal has a bright polished surface, very little oil is required, but if the surface be matted or dead, it requires more care with the oil. A slip of card-board or tin is now bound round the edge of the medal, the edge of which slip should rise about one-fourth of an inch higher than the highest part on the face of the medal. This done, hold the medal with its rim a little sloping, then pour the wax in the lowest portion, and gently bring it level, so that the melted wax may gradually flow over; this will prevent the formation of air-bubbles. Care must be taken not to pour the wax on too hot, as that is one great cause of failure in getting good moulds; it should be poured on just as it is beginning to set in the dish. As soon as the composition poured on the medal is set (becomes solid), undo the rim, for if it was allowed to remain on till the wax became perfectly cool, the wax would adhere to it, and would be liable to crack from shrinking. Put the medal and wax in a cool place, and in about an hour the two will separate easily. When they adhere, the cause is either that too little oil has been used, or that the wax was poured on too hot.

3676. To Take Wax Moulds from Plaster. If the object from which the mould is to be taken, which we assume to be a medal, be composed of plaster of Paris, and the mould is to be taken in wax, the first operation is to prepare the plaster medal. Some boiled linseed oil, such as is used by house painters, is to be laid over the surface of the medal with a camel's-hair pencil, and continued until it is perfectly saturated, which is known by the plaster ceasing to absorb any more of the oil. This operation succeeds best when the medal is heated a little. The medal should now be laid aside till the oil completely dries, when the plaster will be found to be quite hard, and having the appearance of polished marble; it is, consequently, fit to be used for taking the wax mould, which is done in the same manner as we have described for taking a wax mould from a metallic medal. (*See No.* 3675.) Many prefer saturating the medal with water. This is best done by placing the medal back down in the water, but not allowing it to flow over the face; the water rises, by capillary attraction, to the surface of the medal, rendering the face damp without being wet. The rim being now tied on the plaster medal, the melted wax is poured upon it. This method is equally good, but liability to failures is much greater, caused generally by the wax being too hot. The plaster medal may be saturated with skimmed milk and then dried; by repeating this twice, the plaster assumes on the surface an appearance like marble, and may be used for taking wax moulds.

3677. To Take Moulds in Plaster. If a plaster of Paris mould is to be taken from the metallic medal, the preparation of the medal is the same as described in No. 3676; and when so prepared with the rim of card-board or tin, get a basin with as much water in it as will be sufficient to make a proper sized mould (a very little experience will enable the operator to know this), then take the finest plaster of Paris and sprinkle it into the water, stirring it till the mixture becomes of the consistence of thick cream; then pour a small portion upon the face of the medal, and, with a brush similar to that used for oiling it, gently brush the plaster into every part of the surface, which will prevent the formation of air-bubbles; then pour on the remainder of the plaster till it rises to the edge of the rim: if the plaster is good, it will be ready for taking off in an hour. The mould is then to be placed before a fire, or in an oven, until quite dry, after which it is to be placed, back downwards, in a shallow vessel containing melted wax, not of sufficient depth to flow over the face of the mould, allowing the whole to remain over a slow fire until the wax has penetrated the plaster, and appears upon the face. Having removed it to a cool place to harden, it will soon be ready for electrotyping. Glycerine affords an excellent coating for the interior of plaster moulds, to prevent the melted wax from adhering to the inside of the mould.

3678. To Take Moulds of Plaster from Plaster Models. When a plaster mould is to be taken, the face of the model is prepared differently to that described, in order to prevent the adhesion of the two plasters. The best substance for this purpose is a mixture of soft soap and tallow, universally used by potters for preparing their moulds, and called by them lacquer. It is prepared in the following manner: ¼ pound soft soap is put into 3 pints clean water, which are set on a clear fire, and kept in agitation by stirring; when the mixture begins to boil, add from 1 to 1¼ ounces tallow, and keep boiling till it is reduced in bulk to about 2 pints, when it is ready for use. The surface of the medal must be washed over with this lacquer, allowing it to absorb as much as it can, when it assumes the appearance of polished marble; it is now prepared with a rim of paper, and the mould taken as directed for taking plaster moulds. (*See No.* 3677.) When hardened, they will separate easily. Wetting the plaster model with a solution of soap before taking the cast will do, or, if the plaster model has been saturated with oil or milk, it has only to be moistened with sweet oil the same as a metal model.

3679. To Take Moulds of Fusible Alloy from Plaster Models. If a mould of fusible metal be required from a plaster model, the plaster may be saturated either with boiled oil (*see No.* 3676), or the soap and tallow lacquer (*see No.* 3678), and the mould taken in the same manner as from a metallic medal. (*See No.* 3677.)

3680. Copper Moulds from Plaster. Many electro-metallurgists prefer taking a mould in copper when the medal is of plaster of Paris. This is done by the electrotype process (*see No.* 3671); the plaster model is saturated with wax over a slow fire, as already detailed, and then prepared for taking an electrotype in the usual manner (*See No.* 3672, *&c.*) We need hardly mention that the model in this case is destroyed; but, notwithstanding, in the case of plaster models, to take a copper mould is the most preferable, as it may be repaired in case of slight defect, and it may be used over and over again without deterioration. When an electrotype is required of a model that is undercut, or of a bust or figure, the process which we have described will not answer, as the mould cannot separate from the model. In such circumstances the general method of proceeding is to part the mould in separate pieces, and then join these together. The material used for this purpose is plaster of Paris. The operation, however, to be well done, requires a person of considerable experience.

3681. To Take Moulds in Gutta-Percha. Gutta-percha, as a material for moulding, serves the purpose most admirably. The method adopted for taking moulds is to heat the gutta-percha in boiling water, or in a chamber heated to the temperature of boiling water, which makes it soft and pliable. The medal is fitted with a metallic rim, or placed in the bottom of a metal saucer with a cylindrical rim a little larger than the medal; the medal being placed back down, a quantity of gutta-percha is pressed into the saucer, and as much added as will cause it to stand above the edge of the rim. It is now placed in a common copying-press and kept under pressure until it is quite cold and hard. The impressions taken this way are generally very fine. When the medal is not deep cut a less pressure may suffice, but when the pressure is too little the impression will be blunt. Gutta-percha takes a coating of black lead readily, and the deposit goes over it easily. A mixture of gutta-percha and marine glue has been recommended for moulds as superior to gutta-percha alone. This method of moulding by pressure is adopted, in principle, by printers, for making electrotype plates from type and engravings, employing sheets of prepared wax, at a temperature which gives it the proper consistency.

3682. To Mould the Face of a Person in Wax. Take 1 pound new wax, ½ pound resin, melt them at a slow fire, let them cool till you can endure some of it on your hand without burning it; then, having oiled the face with olive oil, and covered the hair of the eye-lids and eye-brows with paste, with a brush nimbly cover the face about the thickness of a quarter of a dollar, being careful not to stop the nostrils, and that the person does not close his eyes firmly enough to wrinkle his face, because that will render the face deformed. Take the wax off gently, and strengthen it with clay on the back, that it may not give way. After this manner you may cast all sorts of faces; laughing, weeping, or wry faces; also fruits or anything else, dividing the mould into two pieces with a warm knife; then fortify them with clay and join them together.

3683. To Mould Figures in Paste. Take the crumbs of a new drawn white loaf, mould it until it becomes as close as wax, and very pliable; beat it, and roll it with a rolling-pin, as fine and as far as it will go; then apply it to the figure to be moulded; dry it in a stove, and it will be very hard; and to preserve it from vermin, you may mix a little powder of aloes with it.

3684. Composition for Taking Moulds of Medals, &c. Melt together equal parts of spermaceti, stearine or hard tallow, and white wax. Or: Mix together by melting, ¾ pound black resin, ¼ pound hard tallow, and 6 ounces bees' wax. This last is more adapted for coarse work, such as architectural ornaments, &c., and is poured on the object to be copied (previously oiled) in a melted state. Articles in plaster of Paris must be first soaked in water, observing that none remains on the surface so as to interfere with the design.

3685. To Make and Use Elastic Moulding. The process patented by Mr. Parks for taking a mould of any kind of model in one piece, is excellently adapted for the electrotypist. The material is composed of glue and molasses. 12 pounds glue are steeped for several hours in as much water as will moisten it thoroughly; this is put into a metallic vessel, which is placed in a hot bath of boiling water. When the glue falls into a fluid state, 3 pounds of molasses are added, and the whole is well mixed by stirring. Suppose, now, that the mould of a small bust is wanted, a cylindrical vessel is chosen so deep that the bust may stand in it an inch or so under the edge. The inside of this vessel is oiled, a piece of stout paper is pasted on the bottom of the bust to prevent the fluid mixture from going inside, and if it is composed of plaster, sand is put inside to prevent it from floating. It is next completely drenched in oil and placed upright in the vessel. This done, the melted mixture of glue and molasses is poured in till the bust is submerged to the depth of an inch. The whole must stand for at least 24 hours, till it is perfectly cool throughout—after which it is taken out by inverting the vessel upon a table, when, of course, the bottom of the bust is presented bare. The mould is now cut by means of a sharp knife, from the bottom up the back of the bust to the front of the head. It is next held open by the operator, when an assistant lifts out the bust and the mould is allowed to re-close. A piece of brown paper is tied round it to keep it firm. The operator has now a complete mould of the bust in one piece; but he cannot treat it like wax moulds, as its substance is soluble in water, and would be destroyed if put into the solution. A mixture of wax and resin, with occasionally a little suet, is melted and allowed to stand till it is on the point of setting, when it is poured carefully into the mould and left to cool. The mould is then untied and opened up as before; the wax bust is taken out, and the mould may be tied up for other casts. Besides wax and resin, there are several other mixtures used—deer's fat is preferable to common suet, stearine, etc. The object is to get a mixture that takes a good cast and becomes solid at a heat less than that which would melt the mould.

3686. To Take Moulds of Figures. If the model or figure be composed of plaster of Paris, a mould is often taken in copper by deposition. The figure is saturated with wax (*see No.* 3688), and copper deposited upon it sufficiently thick to bear handling without damage when taken from the model. The figure with the copper deposit is carefully sawn in two, and then boiled in water, by which the plaster is softened and easily separated from the copper, which now serves as the mould in which the deposit is to be made. It is prepared in the same way as we have described for depositing in copper moulds. (*See No.* 3672.) When the deposit is made sufficiently thick, the copper mould is peeled off, and the two halves of the figure soldered together. The copper moulds which are deposited upon the wax models taken in the elastic moulding are often treated in the same manner; but more generally these moulds are used for depositing silver or gold into them, to obtain fac-similes of the object in these metals, in which case the copper moulds are dissolved off by acids.

3687. To Coat Figures with Copper. When plaster busts or figures are wanted in copper, the usual way is to prepare the figure with wax (*see No.* 3688) and to coat it over with a thin deposit of copper, letting the copper remain. Some operators, when it can be done, remove the plaster and wash over the inside with an alloy of tin and lead melted. In this case the copper must previously be cleaned by washing first in a solution of potash, and then with chloride of zinc. The latter mode will cause the alloy to adhere to the copper and give it strength. In either of these cases the deposit must not be very thick, or it will throw the figures out of proportion, such as the features of a bust, etc. Any slight roughness of deposit may be easily smoothed down by means of fine emery or glass paper. (*See No.* 1935.)

3688. To Prepare a Plaster Cast for Electrotyping. First dry the plaster cast in the oven thoroughly, then get equal parts of bees' wax and common resin, melt them together, and boil the cast until it will not absorb any more; when cold, get some good black lead and cover the cast entirely, not thick, but a bright surface. (*See No.* 3689.)

3689. To Prepare Non-Metallic Moulds to Receive Deposit. Were any of the plaster or wax moulds, described above, attached to the zinc and immersed in the copper solution in the same manner as described in No. 3669, no deposit would be obtained, because neither the plaster nor the wax is a conductor of electricity. Some substance must now be applied to the surface in order to give it conducting power. There are several ways of communicating this property, but the best and most simple for the articles under consideration is to apply common black lead (carburet of iron) in the following manner: A copper wire is put round the edge of the medal, or, if wax moulds are used, a thin slip of copper may be inserted into the edge of the mould—or, being slightly heated and laid upon the back, the two will adhere. A fine brush is now taken (a small hat brush is very suitable) and dipped into fine black lead, and brushed over the surface of the metal. The brushing is to be continued until all the face round to the wire upon the edge, or slip of copper forming connection, has a complete metallic lustre. A bright polish is necessary to obtain a quick and good deposit. In brushing on the black lead, care should be taken not to allow any to go upon the back or beyond the copper connection, or the deposit will follow it, and so cause a loss of copper, and make the mould more difficult to separate from the deposit; being, as it were, incased. When the face of the mould is properly black-leaded, the copper wire connected with it is attached to the zinc plate in the porous cell, and the mould immersed in the copper solution; the deposit will immediately begin upon the copper connection, and will soon spread over every part, completely covering the black-lead surface. When the deposit is considered sufficiently thick for removing—which, in ordinary circumstances, will require from 1 to 3 days—the medal is taken out of the solution, and washed in cold water, and the connection is taken off. If the deposit has not gone far over the edge of the mould, the two may be separated by a gentle pull; if otherwise, the superfluous deposit must be eased off, and if care be taken the wax may be fit to use over again; but when the mould is plaster of Paris, however well it may be saturated with wax, it is seldom in a condition to use again. If the plaster mould be large and thick, it is advisable to coat the back with wax or tallow, which is done by brushing it over with either substance in a melted state; the mould, being cold, will not absorb the wax or tallow; hence it may be recovered again. The sulphate of copper possesses so penetrating a quality that if the slightest imperfection occurs in the saturation of the mould by wax, the solution will penetrate through it, and the copper will be deposited upon the face of the object adhering to the plaster, giving to the metal a rough, matted appearance, and seriously injuring it.

3690. To Use Metal Moulds. The mould in fusible alloy does not require to be black-leaded, but the surface to be electrotyped must be prepared with turpentine, &c., (*see No.* 3673), and the back and edge must be protected by a coating of wax or other non-conducting material; it may be connected with the zinc pole by putting a wire round its edge previous to laying on the non-conducting substance, such as tallow or wax, which should also cover the wire. Or a slip of copper or wire may be laid upon the back, and fastened by a drop or two of sealing-wax; the back is then coated, but care must be taken that the wax does not get between the connection and the medal, which will prevent deposit. The deposit on this mould goes on instantaneously. When sufficiently thick, it may be taken off in the same manner as from the wax mould. These moulds may be used several times, if care be taken not to heat them, as they easily melt. The medals obtained from metallic moulds prepared with the turpentine solution have a bright surface, which is not liable to change easily, but if the mould has been prepared with oil or composed of wax or plaster, the metal will either be dark, or will very easily tarnish. For the means of preserving them by bronzing *see Nos.* 3771, *&c.*

3691. Precautions on Putting the Moulds into a Solution. In putting moulds into the copper solution, the operator is often annoyed by small globules of air adhering to the surface, which either prevent the deposit taking place upon these parts, or, when they are very minute, permit the deposit to grow over them—causing small hollows in the mould, which give a very ugly appearance to the face of the medal. To obviate this, give the mould, when newly put into the solution, two or three shakes, or give the wire attached to it, while the mould is in the solution, a smart tap with a key or knife, or anything convenient; but the most certain means we have tried, is to moisten the surface with alcohol just previous to putting it into the copper solution. A little practice in these manipulations will soon enable the operator to avoid these annoyances.

3692. Electrotyping on Large Objects. When busts or figures, whether of wax or plaster of Paris, are to be coated with copper, with no other conducting surface than black-lead, it is attended with considerable difficulty to the inexperienced electrotyper. The deposit grows over all the prominent parts, leaving hollow places, such as armpits, neck, etc., without any deposit; and when once missed, it requires considerable management to get these parts coated, as the coated parts give a sufficient passage for the current of electricity. It is recommended by some electrotypists to take out the bust, and coat the parts deposited upon the wax, to prevent any further deposit on them; but this practice is not good, especially with plaster of Paris, for an electrotype ought never to be taken out till finished. Sometimes the resistance of the hollow parts is occasioned by the solution becoming exhausted from its position in regard to the positive pole. In this case a change of position effects a remedy. It may be remarked that when a bust or any large surface having hollow parts upon it, is to be electrotyped, as many copper connections as possible ought to be made between these parts and the zinc of the battery. Let the connections with the hollow parts be made with the finest wire which can be had, and let the zinc plate in the cell have a large surface compared to the surface of the figure, and the battery be of considerable intensity; if attention is paid to these conditions, the most intricate figures and busts may be covered over in a few hours. Care has to be observed in taking off the connections from the deposit, or the operator may tear off a portion of the deposit; if the wires used are fine, they should be cut off close to the deposited surface.

3693. To Coat Busts and Figures. Busts and figures, and other complicated works of art, which cannot be perfectly coated with black-lead, may be covered by a film of silver or gold, which serves as a conducting medium to the copper. This is effected by a solution of phosphorus in sulphuret of carbon. The solution of phosphorus is prepared by adding to each pound of that substance 15 pounds bisulphuret of carbon, and then thoroughly agitating the mixture; this solution is applicable to various uses, and, amongst others, to obtaining deposits of metal upon non-metallic substances, either by combining it with the substances on which it is to be deposited, as in the case of wax, or by coating the surface thereof. Any of the known preparations of wax may be treated in this way, but the one preferred is composed of from 6 to 8 ounces of the solution, 5 pounds wax, and 5 pounds deer's fat, melted together at a low heat, on account of the inflammable nature of the phosphorus. The composition thus obtained is acted upon by an electrotyping solution as readily as if it were coated with the black-lead.

3694. To Gild or Silver-Plate Flowers, &c. If the solution of phosphorus (*see No.* 3693) is to be applied to the surface of the article, an addition is made to it of 1 pound wax or tallow, 1 pint spirits of turpentine, and 2 ounces pure India-rubber (dissolved with 1 pound asphalt, in bisulphuret of carbon), for every pound phosphorus contained in the solution. The wax and tallow being first melted, the solution of India-rubber and asphalt is stirred in; then the turpentine, and after that the solution of phosphorus is added. The solution prepared in this manner is applied to the surfaces of non-metallic substances, such as wood, flowers, etc., by immersion or brushing; the article is then immersed in a dilute solution of nitrate of silver or chloride of gold; in a few minutes the surface is covered with a fine film of metal, sufficient to ensure a deposit of any required thickness on the article being connected with any of the electrical apparatus at present employed for coating articles with metal. The solution intended to be used is prepared by dissolving 4 ounces silver in nitric acid, and afterwards diluting the same with 12 gallons water; the gold solution is formed by dissolving 1 ounce gold in nitro-muriatic acid (aqua regia), and then diluting it with 10 gallons water. The solutions of silver and gold, prepared as above, will last for a long time, and serve for a great many articles. When it is convenient it is best to use both solutions. The connecting wire should first be attached to the article to be coated, before being dipped into the phosphorus solution, but connected at such parts as will not hurt the appearance of the object by leaving a mark when it is taken off. Care should be taken not to touch the article with the hands after it is dipped into the solution. The object supported by the connections is immersed in the phosphorus solution, where it remains for two or three minutes. When taken out it is dipped into the silver solution, and, as soon as the surface becomes black, having the appearance of a piece of black china, it is to be dipped several times in distilled water, and then immersed in the solution of gold about three minutes; the surface takes a bronze tinge by the reduction of the gold. It is next washed in distilled water by merely dipping, not by throwing water upon it. The wire connection is now attached to the zinc of the battery, and then the article put into the copper solution, and in a few minutes the article is coated over with a deposit of copper. A thin copper surface may thus be given to small busts or figures without sensibly distorting the features.

3695. Electrotyping on Wood. Dip the wood in melted wax, then brush over with black-lead until polished; insert a wire of copper, and see that it is also covered with the plumbago, and in contact with that already on the wood; now attach to the pole of the battery, and immerse in the solution of sulphate of copper. The battery should not be too strong.

Electroplating.

The foregoing matter refers to electrotyping, that is, copper-coating, by galvanism. Electroplating, or coating with silver, is conducted in a similar manner to electrotyping as far as general principles and manipulation are concerned, but differs in the solutions used, as well as in the preparation of the objects to be electroplated.

3697. To Prepare Cyanide of Silver. First dissolve 1 ounce pure silver in 2 ounces nitric acid and 2 ounces hot water, after which further dilute with 1 quart hot water. The propriety of diluting the nitrate of silver before precipitating by the cyanide of potassium arises from the fact that the salts of potash and soda (such as the nitrates, chlorides, and sulphates), when in strong solution, dissolve small quantities of the silver salt, and thus cause a loss, which is prevented by previous dilution with water. The nitric acid used must be free from hydrochloric (muriatic) acid; to a small quantity of the acid add a few drops of solution of nitrate of silver; if it gives a milky white precipitate, it contains muriatic acid, and should be rejected. Then dissolve 5 ounces cyanide of potassium in 1 quart water. Add this by degrees to the silver solution until the whole of the silver is precipitated, which may be tested thus: Stir the mixture and allow it to settle; then drop into the clear liquid a very small quantity of the second preparation, from the end of a glass rod; if the clear liquid is rendered turbid, it is a proof that the whole of the silver is not separated; but if the liquid remains unchanged, it shows that the silver is entirely separated. The clear liquid is then to be poured off, and the precipitate, which is cyanide of silver, washed at least 4 times in hot water, dried and bottled for use. The use and handling of cyanide of potassium requires great caution, as 11 grains of it are sufficient to kill a grown person. The fumes thrown off while dissolving the silver in nitric acid are also highly deleterious, and must not be inhaled; it is better, therefore, not to dissolve silver in a close room.

3698. To Make Silver Solution. The solution of silver used for plating consists of cyanide of silver dissolved in potassium, adding a solution of cyanide of potassium to the cyanide of silver until it is all dissolved. The resulting solution constitutes the cyanide of potassium and silver, and forms the plating solution. It ought to be filtered previous to using, as there is always formed a black sediment, composed of iron, silver, and cyanogen, which, if left in the solution, would fall upon the surface of the article receiving the deposit, and make it rough. The sediment, however, must not be thrown away, as it contains silver. The cyanide of potassium, used to dissolve the cyanide of silver, may be so diluted that the plating solution, when formed, shall contain 1 ounce of silver in the gallon; of course the proportion of silver may be larger or smaller, but that given is best for plating. In dissolving 100 ounces of silver, the following proportions of each ingredient are those which have been found in practice to be the best. Take 7 pounds of the best nitric acid, and 61 ounces of cyanide of potassium, of the average quality; this quantity will precipitate the 100 ounces of silver dissolved in the acid solution. After this is washed, take 62 ounces more of cyanide of potassium, the solution of which will dissolve the precipitate; this being done, the plating solution is then formed. Of course these proportions will vary according to the difference in the quality of the materials; but they will serve to give an idea of the cost of the silver solution prepared in this manner.

3699. To Dissolve Cyanide of Silver in Yellow Prussiate of Potash. Dissolve the cyanide of silver by yellow prussiate of potash (ferrocyanide of potassium), 3 pounds of which are required to dissolve 1 ounce of silver. This forms an excellent plating solution, and yields a beautiful surface of silver. It must have a weak battery power, and consequently the silver is very soft. The positive electrode does not dissolve in this solution; there is formed upon its surface a white scaly crust, which drops off and falls to the bottom; and the solution soon becomes exhausted of silver, and will need to be renewed.

3700. Solution Made with Oxide of Silver. A good silver solution for electroplating white metal and brass is made by dissolving 1 part oxide of silver in 8 parts cyanide of potassium and 64 parts warm water. Oxide of silver is made by precipitating a solution of the nitrate by a dissolved alkali like potassa or baryta.

3701. To Make Silver Solution by the Battery. The best and cheapest method of making up the silver solution is by the battery, which saves all expense of acids and the labor of precipitation. To prepare a silver solution which is intended to have an ounce of silver to the gallon, dissolve 123 ounces cyanide of potassium in 100 gallons water; get one or two flat porous vessels, submerge them in this solution to within half an inch of the rim, and fill them to the same height with the solution; in these porous vessels place small plates or sheets of iron or copper, and connect them with the zinc pole of a battery; in the solution outside the shallow vessels place a sheet or sheets of silver connected with the *silver pole* of the battery. This arrangement being made at night, and the power employed being a Smee's battery of 6 cells, the zincs 7 inches square, it will be found in the morning that there will be dissolved 60 to 80 ounces of silver from the sheets. The solution is now ready for use; and by observing that the articles to be plated have less surface than the silver plate forming the positive electrode, for the first two days, the solution will then have the proper quantity of silver in it. Occasionally a little silver is found in the porous cell; it is therefore not advisable to throw away the solution in them without first testing it for silver, which is done by adding a little muriatic acid to it. The amateur electrotypist may, from this description, make up a small quantity of solution for silvering his medals or figures. For example, a half-ounce of silver to the gallon of solution will do very well; a small quantity may be prepared in little more than an hour. As the cyanide of potassium dissolves silver without the aid of a battery, a plating liquor may be formed by merely allowing a piece of silver to steep in this solution for a few days; but this is tedious and uncertain, although for small operations, and where porous vessels are not convenient, it will serve the purpose.

3702. To Recover Silver from Solution. When a silver solution gets out of order, and cannot be rendered fit for use again, the silver may be recovered by adding to the solution any acid that will neutralize the alkali; if nitric or sulphuric acid be used, the silver precipitates as cyanide, but if hydrochloric acid be used, the silver will be precipitated as a chloride; in either case the solution should be diluted, or a portion of the precipitate will be redissolved. The precipitate is allowed to deposit, the clear liquor decanted, and the vessel filled with water to wash the precipitate, which is afterwards collected upon a filter and dried, and then mixed with twice its weight of carbonate of potash, and fused in a Hessian crucible for 15 minutes, or until the fused fluid ceases to effervesce. On removing the crucible, and pouring the whole into an iron ladle, when cool the silver will be found in the metallic state at the bottom of the ladle. In these operations, when pouring the acid into the cyanide solution, great care must be taken not to inhale the fumes given off, which are very abundant and poisonous. The operation should be done in the open air, and even then it is bad. Instead of throwing down the silver by an acid, it is better to evaporate the solution to dryness, and to fuse the product as described; in which case the cyanide is an excellent reducing flux, requiring no addition of carbonate of potash, and saves the necessity of evolving poisonous fumes.

3703. Test for Free Cyanide of Potassium in Solutions. If we dissolve a small quantity of sulphate of copper and add to it an excess of ammonia, there is produced a deep blue color. Cyanide of potassium will destroy the blue color, in a fixed chemical proportion. To obtain this proportion, take ten grains of pure cyanide of potassium and dissolve in water; then take a certain quantity, say 100 grains, of sulphate of copper, and convert it into ammoniuret, the whole measuring a given quantity, and pour from an alkalimeter this blue liquor into the cyanide of potassium till it ceases to destroy the color, then mark the number of graduations required, and that amount of copper solution will represent 10 grains cyanide of potassium—a quantitative test will thus be got for the full cyanide of potassium in the solution, and should be used as follows: Say that the color of 60 graduations of the blue solution was destroyed by the 10 grains of cyanide of potassium; then, to test the quantity of free cyanide of potassium in the plating solution, take 60 graduations of the blue liquor in any convenient vessel, and add to it from an alkalimeter the plating solution, till the color of the blue liquor is destroyed, then note the quantity which contains 10 grains free cyanide, from which the quantity in the whole solution may be calculated.

3704. Test for the Quantity of Free Cyanide of Potassium in Solutions. It has been already mentioned that the cyanide of silver, as it forms upon the surface of the silver plate, is dissolved by the cyanide of potassium. This renders it necessary to have always in the solution free cyanide of potassium. Were we to use the pure crystalline salt of cyanide of potassium and silver, dissolved in water, without any free cyanide of potassium, we should not obtain a deposit beyond a momentary blush, as the silver plate or electrode would get an instantaneous coating of cyanide of silver, and this not being dissolved, the current would stop. The quantity of free cyanide of potassium required in the solution varies according to the amount of silver that is present, and the rapidity of the deposition. If there be too little of it, the deposit will go on slowly; if there be too much, the silver plate will be dissolved in greater proportion than the quantity deposited, and the solution will consequently get stronger. The proportion we have found best is about half by weight of free cyanide of potassium to the quantity of silver in solution; thus, if the solution contains 2 ounces of silver to the gallon, it should have 1 ounce of free cyanide of potassium per gallon. This is known by taking some nitrate of silver, dissolving it in distilled water and placing it in a common alkalimeter (*see No.* 62), graduated into 100 parts. The proportion of the nitrate of silver in the solution is to be such that every two graduations of the solution should contain 1 grain. A given quantity of the plating solution is now taken—say 1 ounce by measure, and the test solution of nitrate of silver is added to it by degrees, so long as the precipitate formed is redissolved. When this ceases the number of graduations is then noted, and the following equation gives the quantity of free cyanide. Every 175 nitrate of silver are equal to 130 cyanide of potassium in solution. Suppose 20 graduations were taken, equal to 10 grains nitrate of silver, then 175 : 130 :: 10 : 7.4 grains free cyanide of potassium. This, multiplied by 160, the number of fluid ounces per gallon, will make about 2½ ounces. We have taken 2 graduations to 1 grain of nitrate of silver, that the solution may be considerably dilute and less liable to error. The following table is calculated at a half grain nitrate of silver to the graduation, and will be a guide to the student or workman. The quantity of solution tested is 1 ounce by measure.

Number of graduations used.	Free cyanide per gallon.		
	oz.	dwt.	gr.
1	0	2	13
2	0	5	3
3	0	7	16
4	0	10	6
5	0	12	19
6	0	15	9
7	0	17	22
8	1	0	13
9	1	3	1
10	1	5	12
11	1	8	5
12	1	10	19
13	1	13	8
14	1	15	22
15	1	18	11
16	2	1	2
17	2	3	14
18	2	6	2
19	2	8	11
20	2	11	0

3705. To Cleanse Articles for Electroplating. Articles that are to be plated are first boiled in an alkaline lye, to free them from grease, then washed from the lye, and dipped into dilute nitric acid, which removes any oxide that may be formed upon the surface; they are afterwards brushed over with a hard brush and fine sand. (*See No.* 3381.) The alkaline lye should be in a caustic state, which is easily effected by boiling the carbonated alkali with slacked lime, until, on the addition of a little acid to a small drop of the solution, no effervescence occurs. (*See No.* 101.) The lime is then allowed to settle, and the clear liquor is fit for use. The lye should have about ¼ pound soda-ash, or pearl-ash, to the gallon of water. The nitric acid, into which the article is dipped, may be diluted to such an extent that it will merely act upon the metal. Any old acid will do for this purpose. In large factories the acid used for dipping before plating is generally afterwards employed for the above purpose of cleaning.

3706. To Prepare Articles for the Decomposing Cell. The article being thoroughly cleaned and dried, has a copper wire attached to it, either by twisting it round the article or putting it through any open part of it, to maintain it in suspension. It is then dipped into nitric acid as quickly as possible, and washed through water, and then immersed in the decomposing cell containing silver solution, suspending it by the wire which connects with the zinc pole of the battery. The nitric acid generally used and found best for dipping has a specific gravity 1.518, and contains 10 per cent. sulphuric acid. The article is instantaneously coated with silver, and ought to be taken out after a few seconds and well brushed. On a large scale, brushes of brass wire attached to a lathe are used for this purpose; but a hard hair brush with a little fine sand will do for small work. This brushing is used in case any particle of foreign matter may be still on the surface. It is then replaced in the solution, and in the course of a few hours a coating of the thickness of tissue paper is deposited on it, having the beautiful matted appearance of dead silver. Any thickness of silver may be given to a plate by continuing the operation a proper length of time. 1½ to 1¾ ounces of silver to the square foot of surface will give an excellent plate about the thickness of ordinary writing paper. We may remark that, in depositing silver from the solution, a weak battery may be used; though when the battery is weak the silver deposited is soft, but if used as strong as the solution will allow, the silver will be equal in hardness to rolled or hammered silver. If the battery is stronger than the solution will stand, or the article very small compared to the size of the plate of silver forming the positive electrode, the silver will be deposited as a powder. Gas should never be seen escaping from either pole; and the surface of the article should always correspond as nearly as possible with that of the positive electrode, otherwise the deposit runs the risk of not being good; it requires more care, and the solution is apt to be altered in strength, because if the positive electrode be large compared with the negative, the solution will become stronger in silver, while if smaller in proportion the solution will become exhausted of silver.

3707. To Silver-plate Large Articles (such as those plated in factories), it is not always sufficient to dip them in nitric acid; wash and immerse them in the solution, in order to effect a perfect adhesion of the two metals. To secure this, a small portion of quicksilver is dissolved in nitric acid, and a little of this solution is added to water, in sufficient quantity to enable it to give a white silvery tint to a piece of copper when dipped into it; the article then, whether made of copper, brass, or German silver, after being dipped in the nitric acid and washed, is dipped into the nitrate of mercury solution till the surface is white; it is then well washed by plunging it into two separate vessels containing clean water, and finally put into the plating solution. This secures perfect adhesion of the metals. One ounce of quicksilver thus dissolved will do for a long time, though the liquor is used every day. When the mercury in this solution is exhausted, it is liable to turn the article black upon being dipped into it; this must be avoided, as in that case it also causes the deposited metal to strip off.

3708. To Preserve the Dead, Matted Appearance of Silver after Electroplating. If it is desired to preserve the surface in this condition, the article must be taken out of the electroplating solution, care being taken not to touch it by the hand, and immersed in boiling distilled water for a few minutes. On being withdrawn, sufficient heat has been imparted to the metal to dry it instantly. If it is a medal, it ought to be put in an air-tight frame immediately, or if a figure, it may be at once placed under a glass shade, as a very few days' exposure to the air tarnishes it, by the formation of sulphuret of silver, especially in a room where there is fire or gas.

3709. To Remove the Chalky Appearance of Silver after Plating. When articles are taken out of the electroplating solution they are swilled in water, and then put into boiling water. They are afterwards put into hot sawdust, which dries them perfectly. Their color is chalk-white. They are generally weighed before being scratch-brushed; that is, brushed with fine wire brushes (*see Nos.* 3381 *and* 3706), and old ale, beer, or water containing in solution a little gum, glue, or sugar, but the amateur may use a hard hair brush. It may be afterwards burnished according to the usual method of burnishing, by rubbing the surface with considerable pressure with polished steel or the mineral termed bloodstone. Although this operation does not displace any of the silver, still, in taking off the chalky appearance, there is a slight loss of weight. The appearance after scratching is that of bright metallic silver.

3710. To Increase the Brightness of the Deposit. A little sulphuret of carbon added to the plating solution prevents the chalky appearance, and gives the deposit the appearance of metallic silver; the reaction which takes place in this mixture is not yet understood. The best method of applying the sulphuret of carbon is to put one or two ounces into a large bottle, then fill it with strong silver solution having an excess of cyanide of potassium, and let it repose for several days, shaking it occasionally. A little of this silver solution is added, as required, to this plating solution, which will give the articles plated the same appearance as if scratched. It is also found that the presence of sulphuret of carbon prevents the solution from going out of order; indeed, we have seen a solution that has been constantly working from two to three years, while, generally, they were subject to go out of order for a time, in less than one year—although, after standing a time, they would recover—but these are curious reactions not yet investigated.

3711. To Insure Success in the Electroplating Process. In order to insure success in silver-plating upon metals and metallic alloys, two solutions of silver are requisite; the first, to whiten or fix the silver to such metals as iron, steel, britannia metal, and German silver; the second, to finish the work, as any amount of pure silver can be deposited from the second solution.

3712. First, or Whitening Solution. Dissolve 2¼ troy pounds cyanide of potassium, 8 ounces carbonate of soda, and 5 ounces cyanide of silver in 1 gallon rain or distilled water. This solution should be used with a compound battery of 3 to 10 pairs, according to the size of the work to be plated. The use of this solution will insure the adhesion of silver to all kinds of brass, bronze, type metal, &c., without employing mercury, the frequent use of which is injurious to the health of the operator.

3713. Second, or Finishing Solution. Dissolve 4½ troy ounces cyanide of potassium, and 1¼ ounces cyanide of silver, in 1 gallon rain or distilled water. This solution should be used with one large cell of Smee's battery, observing that the silver plate is placed as near the surface of the articles to be plated as possible.

3714. Boettger's Test for the Silver on Silver-Plated Metals. The test fluid consists of a saturated solution of bichromate of potassa in nitric acid, specific gravity 1.2. Any dirt or varnish having been removed by strong alcohol from the metallic surface to be tested, a drop of the test fluid is applied to it by means of a glass rod, and immediately afterwards washed off with some cold water. If pure silver is present (as regards silver coins, these are left in contact with the test fluid for a greater length of time), there will appear clearly a blood-red colored mark (chromate of silver). Upon German silver the test liquid appears brown, but after washing with water the blood-red colored mark does not appear; the so-called britannia-metal is colored black; on platinum no action is visible; metallic surfaces coated with an amalgam of mercury yield a reddish speck, which, however, is entirely washed off by water; on lead and bismuth the test liquid forms a yellow-colored precipitate; zinc and tin are both strongly acted upon by this test liquid, which, as regards the former metal, is entirely removed by water, while, as regards the latter, the test liquid is colored brownish, and addition of water produces a yellow precipitate which somewhat adheres to the tin.

3715. Plating on Iron or Steel. Take 2 quarts rain water, dissolve 2 pounds cyanide of potassium, and filter. In order to plate steel or iron, dip it into pure sulphuric acid for one minute, then clean with pumice stone, and brush; rinse, and hang in solution of cyanide of potassium for three minutes, or until it becomes white; then hang in silver solution until plated heavy enough. (*See No.* 3698.)

3716. Taking Silver from Copper, Etc. First by stripping or dissolving it off; this is done by putting into a stoneware or copper pan some strong sulphuric acid (vitriol), to which a little nitrate of potassa is added; the article is laid into this solution, which will dissolve the silver without materially affecting the copper; nitrate of potassa is added by degrees, as occasion requires; and if the action is slow a little heat is applied to the vessel. The silver being removed, the article is well washed and then passed through the potash solution, and finished for plating. When the sulphuric acid becomes saturated with silver it is diluted, and the silver is precipitated by a solution of common salt; the chloride of silver formed is collected and fused in a crucible with carbonate of potash, when the silver is obtained in a metallic state, as a knob or button. The crucible should not be over two-thirds full, and should be kept in fusion till effervescence ceases. The crucible is then removed from the fire, and, when cool, it is broken. (*See No.* 3702.) The article thus stripped by acids often shows a little roughness, not from the effects of the acid, but because the copper under the silver has not been polished; it is therefore a necessary practice in the electroplating factories to polish the articles before plating. This is done by means of a circular brush, more or less hard as required, fixed upon a lathe, and a thin paste made of oil and pumice-stone ground as fine as flour. By this process the surface of any article can be smoothed and polished; but a little experience is required to ensure success, and enable the operator to polish the surface equally without leaving brush marks. After this the article must be cleaned in potash before it is plated.

3717. To Recover Silver from Copper. Instead of stripping off the silver by means of acid, as in No. 3716, it is a more common and preferable mode to brush off the silver by the operation just described. In this case the brushings must be collected, dried, and burned; this may be done in an iron pan, keeping it at a red heat until all carbonaceous matters are consumed; the remainder is fused with carbonate of soda or potash, when the silver is obtained, in combination with a little copper.

3718. Cyanide of Silver and Potassium, its Decomposition During the Plating Process. The silver salt in the plating solution is a true double salt, being, as already described, a compound of 1 equivalent of cyanide of silver, and 1 of cyanide of potassium—two distinct salts. In the decomposition of the silver solution by the electric current, the former, cyanide of silver, is alone affected; the silver is deposited, and the cyanogen passes to the positive plate or electrode. The cyanide of potassium is therefore set at liberty upon the surface of the article receiving the silver deposit, and its solution, being specifically lighter than the general mass of the plating solution, rises to the top; this causes a current to take place along the face of the article being plated. If the article has a flat surface, suppose that of a waiter or tray, upon which a prominence exists, as a mounting round the edge, it will cause lines and ridges from the bottom to the top. Newly formed solutions are most subject to produce this annoyance.

3719. Dead Silvering for Medals. The perfect smoothness which a medal generally possesses on the surface, renders it very difficult to obtain a coating of dead silver upon it, having the beautiful silky lustre which characterizes that kind of work, except by giving it a very thick coating of silver, which takes away the sharpness of the impression. This dead appearance can be easily obtained by putting the medal, previous to silvering, in a solution of copper, and depositing upon it, by means of a weak current, a mere blush of copper, which gives the face of the medal that beautiful crystalline richness that deposited copper is known to give. The medal is then to be washed from the copper solution, and immediately to be put into the silver solution. A very slight coating of silver will suffice to give the dead frosty lustre so much admired, and in general so difficult to obtain.

3720. To Recover Silver from Old Plated Goods. Oil of vitriol, together with 5 per cent. of nitrate of soda, is heated in a cast-iron boiler, or a stoneware pan, to 212° Fahr. The silver-plated clippings are placed in a sheet-iron bucket or cullender, which is fastened to a pulley that it may be moved about in the acid. As soon as the silver is removed, the cullender is raised, allowed to drain, then immersed in cold water and emptied, to be again used in the same manner. When the acid bath is fresh, the desilvering proceeds very rapidly, and even with heavy plated ware takes but a few minutes; with the gradual saturation of the bath more time is required, and it is readily perceived when the acid must be renewed. The small amount of acid solution adhering to the copper, precipitates its silver when brought into the water. To obtain its complete removal, the clippings, when raised from the desilvering bath, and before immersion in water, may be dipped into a second bath prepared in the same manner, which is afterwards to be used in place of the first. The saturated bath, on cooling, congeals to a crystalline semi-fluid mass of sulphate of copper and of soda. The silver is removed by chloride of sodium (common salt) which is added in small portions at a time, while the solution is yet warm. The chloride of silver separates readily, and is washed and reduced in the usual manner. The acid solution contains but a very small portion of copper, hardly enough to pay for recovering.

3721. To Recover Silver from Copper. This process is applied to recover the silver from the plated metal, which has been rolled down for buttons, toys, etc., without destroying any large portion of the copper. For this purpose, a dissolving solution is composed of 3 pounds oil of vitriol, 1½ ounces nitre, and 1 pound water. The plated metal is boiled in it till the silver is dissolved, and then the silver is recovered by throwing common salt into the solution. (*See No.* 3214.)

3722. Test Fluid for Silver-Plated Goods. For this purpose a testing fluid is prepared by adding pure nitric acid to powdered red chromate of potash, and mixing them in such a manner that a part of the latter remains in suspension, the whole being kept well stirred during the mixing. Equal parts by weight of each may be taken. The nitric must be quite free from hydrochloric acid, and have the proper degree of concentration, being neither too fuming nor too dilute; it should have a specific gravity between 1.20 and 1.25. When the mixture has been prepared for a few hours, and been stirred several times, the reddish-colored liquid is poured off from the residue and kept in a stoppered bottle.

3723. To Test Silver-Plated Goods. The ordinary and very accurate method of testing of silver is founded upon the insolubility of chloride of silver in dilute acids and in water. This otherwise satisfactory test is, however, difficult to carry out when an article is very thinly plated. A drop of the test liquid (see last receipt) is then brought in contact with the metal to be tested, and immediately washed off again with water. If a visible blood-red spot remains, silver is present. This method requires only the following precautions: The metallic surface must have been quite cleansed from grease or varnish with spirits of wine—water must be poured over the treated surface before judging of the color, as that of the testing fluid is altered by the metal, and the red precipitate is not distinctly visible until the colored liquid has been washed off. The red spot can afterwards be very easily removed with the finger. By this method the slightest trace of silver in an alloy may be ascertained. When an article is suspected to be only thinly plated, a very minute drop of the testing fluid should be used. With no other metal or alloy does this red spot, so characteristic of silver, appear; in some cases the testing fluid only corrodes the surface of the metal, whilst in others colored precipitates are formed, which, however, cannot be confounded with those of silver. German silver brought into contact with the testing fluid affords no red spot after being washed. The spot will, however, have been strongly corroded. Britannia metal yields a black spot; zinc is strongly corroded; platinum is not attacked; lead gives a yellow precipitate; tin is strongly affected by the fluid; when the brownish-colored testing fluid is washed off, a yellow precipitate is perceived, which adheres tightly to the metal; copper is strongly attacked, a tarnished surface of this metal is brightened by the action of the acid.

Electro-Gilding.

The operation of gilding, or covering other metals with a coating of gold by the battery, is performed in the same manner as electroplating, with the exception of a few practical modifications.

3725. To Prepare Chloride of Gold. Dissolve 1 part gold in 3 parts nitro-hydrochloric acid (aqua regia); evaporate until vapors of chlorine begin to be disengaged, then set the solution aside to crystallize. Aqua regia consists of 1 part nitric acid and 2 parts (both by measure) muriatic (hydrochloric) acid.

If aqua ammonia be added to a solution of gold in aqua regia, it precipitates a reddish-yellow deposit, which may be collected, washed, and dried. This is the ammoniuret of gold, and must be handled and prepared with great caution, it being the fulminate of gold.

3726. To Prepare a Solution of Gold. Add a solution of cyanide of potassium to a solution of chloride of gold (*see No.* 3725) until all the precipitate is redissolved; but this gives chloride of potassium in the solution, which is not good. In the preparation of the solution by this means there are some interesting reactions. As the chloride of gold has always an excess of acid, the addition of cyanide of potassium causes violent effervescence, and no precipitate of gold takes place until all the free acid is neutralized, which causes a considerable loss to the cyanide of potassium. There is always formed in this deposition a quantity of ammonia and carbonic acid, from the deposition of the cyanate of potash; and if the chloride of gold be recently prepared, and hot, there is often formed some aurate of ammonia (fulminate of gold), which precipitates with the cyanide of gold. Were this precipitate to be collected and dried, it would explode when slightly heated. By previously diluting the chloride of gold, or using it cold, this compound is not formed. After the free acid is neutralized by the potash, further addition of the cyanide of potassium precipitates the gold as cyanide of gold, having a light yellow color; but as this is slightly soluble in ammonia and some of the alkaline salts, it is not advisable to wash the precipitate, lest there be a loss of gold. Cyanide of potassium is generally added until the precipitate is redissolved; consequently much impurity is formed in the solution, namely, nitrate and carbonate of potash with chloride of potassium and ammonia. Notwithstanding, this solution works very well for a short time, and it is very good for operations on a small scale.

3727. To Prepare Cyanide of Gold. Dissolve 1 ounce of fine gold in 28 pennyweights nitric acid and 2 ounces muriatic acid, and add 1 quart hot water. Precipitate with the second preparation used for cyanide of silver (*see No.* 3697), and proceed in the same manner.

3728. To Prepare a Solution of Gold. Dissolve 4 troy ounces cyanide of potassium and 1 ounce cyanide of gold in 1 gallon rain or distilled water. This solution is to be used at about 90° Fahr., with a battery of at least two cells. Gold can be deposited, of various shades to suit the taste, by adding to the gold solution a small quantity of the cyanides of silver, copper, or zinc, and a few drops of hydrosulphuret of ammonia.

3729. To Prepare a Gold Solution by the Battery Process. To prepare a gallon of gold solution, dissolve 4 ounces cyanide of potassium in 1 gallon water, and heat the solution to 150° Fahr.; now take a small porous cell and fill it with this cyanide solution, and place it inside the gallon of solution; into this cell is put a small plate of iron or copper, and attached by a wire to the zinc pole of a battery. A piece of gold is placed into the large solution, facing the plate in the porous cell, and attached to the silver of the battery. The whole is allowed to remain in action until the gold, which is to be taken out from time to time and weighed, has lost the quantity required in solution. By this means a solution of any strength can be made, according to the time allowed. The solution in the porous cell, unless the action has continued long, will have no gold, and may be thrown away. Half an hour will suffice for a small quantity of solution—of course any quantity of solution may be made up by the same means. For all the operations of gilding by the cyanide solution, it must be heated to at least 130° Fahr. The articles to be gilt are cleaned in the way described for silver (*see No.* 3705), but are not dipped into nitric acid previous to being put into the gold solution. 3 or four minutes is sufficient time to gild any small article. After the articles are cleaned and dried they are weighed, and, when gilt, they are weighed again; thus the quantity of gold deposited is ascertained. Any convenient means may be adopted for heating the solution. The one generally adopted is to put a stoneware pan containing the solution into an iron or tin-plate vessel filled with water, which is kept at the boiling point either by being placed upon a hot plate or over gas. The hotter the solution the less battery power is required. Generally a battery of 3 or 4 cells is used for gilding, and the solution is kept at 130° to 150° Fahr. But 1 cell will answer if the solution is heated to 200°.

3730. Process of Electro-Gilding. The process of gilding is generally performed upon silver articles. The method of proceeding is as follows: When the articles are cleaned as described in No. 3705, they are weighed, and well scratched with wire brushes, which cleanse away any tarnish from the surface, and prevents the formation of air-bubbles. They are then kept in clean water until it is convenient to immerse them in the gold solution. One immersion is then given, which merely imparts a blush of gold; they are taken out and again brushed; they are then put back into the solution and kept there for 3 or 4 minutes, which will be sufficient if the solution and battery are in good condition; but the length of time necessarily depends on these two conditions, which must be studied and regulated by the operator.

3731. To Electro-Gild Iron, Tin, and Lead. Iron, tin, and lead are very difficult to gild direct; they therefore generally have a thin coating of copper deposited upon them by the cyanide of copper solution (*see Nos.* 3754 *and* 3755), and immediately put into the gilding solution.

3732. Conditions Required in Electro-Gilding. The gilding solution generally contains from one-half to an ounce of gold in the gallon, but for covering small articles, such as medals, for tinging daguerreotypes, gilding rings, thimbles, etc., a weaker solution will do. The solution should be sufficient in quantity to gild the articles at once, so that it should not have to be done bit by bit; for when there is a part in the solution and a part out, there will generally be a line mark at the point touching the surface of the solution. The rapidity with which metals are acted upon at the surface line of the solution is remarkable. If the positive electrode is not wholly immersed in the solution, it will, in a short time, be cut through at the surface of the water, as if cut by a knife. This is also the case in silver, copper, and other solutions.

3733. To Maintain the Strength of the Gold Solution. As the gold solution evaporates by being hot, distilled water must from time to time be added. The water should always be added when the operation of gilding is over, not when it is about to be commenced, or the solution will not give so satisfactory a result. When the gilding operation is continued successively for several days, the water should be added at night. To obtain a deposit of a good color, much depends upon the state of the solution and battery; it is therefore necessary that strict attention be paid to these, and the more so as the gold solution is very liable to change if the size of the article receiving the deposit is not the same as that of the positive electrode plate. The result of a series of observations and experiments, continued daily throughout a period of nine months, showed that in five instances only the deposit was exactly equal to the quantity dissolved from the positive plate. In many cases the difference did not exceed 3 per cent., though occasionally it rose to 50 per cent. The average difference, however, was 25 per cent. In some cases double the quantity dissolved was deposited, in others the reverse occurred—both resulting from alterations made in the respective processes; for in these experiments, the state of the solution and the relative sizes of the negative and positive electrodes were varied, as far as practicable. The most simple method of keeping a constant register of the state of the solution is to weigh the gold electrode before putting it into the solution; and, when taking it out, to compare the loss with the amount deposited. A little allowance, however, must be made for small portions of metal dissolved in the solution, from the articles that are gilt, which, when gilding is performed daily, is considerable in a year. A constant control can thus be exercised over the solution, to which there will have to be added from time to time a little cyanide of potassium, a simple test of requirement being that the gold positive electrode should always come out clean, for if it has a film or crust it is a certain indication that the solution is deficient of cyanide of potassium. Care must be taken to distinguish this crust, which is occasionally dark-green or black, from a black appearance, which the gold electrode will take when very small in comparison to the article being gilt, and which is caused by the tendency to evolve gas. In this case an addition of cyanide of potassium would increase the evil. The black appearance from the tendency to the escape of gas has a slimy appearance. This generally takes place when the solution is nearly exhausted of gold, of which fact this appearance, taken conjointly with the relative sizes of the electrodes, is a sure guide.

3734. To Regulate the Color of the Gilding. The gold upon the gilt article, on coming out of the solution, should be of a dark yellow color, approaching to brown; but this, when scratched (*see No.* 3709), will yield a beautifully rich deep gold. If the color is blackish it ought not to be finished, for it will never either brush or burnish a good color. If the battery is too strong, and gas is given off from the article, the color will be black; if the solution is too cold, or the battery rather weak, the gold will be light-colored; so that every variety of shade may be imparted. A very rich dead gold may be made by adding ammoniuret of gold (*see No.* 3725) to the solution just as the articles are being put in; or, what is better, add some sulphuret of carbon in the same way as for silver solutions (*see No.* 3710), which affects the color and appearance of the gold in the same way as it does the silver.

3735. To Improve the Color of Gilding. A defective colored gilding may be improved by the help of the following mixture: 3 parts nitrate of potassa (saltpetre), 1½ parts alum, 1½ parts sulphate of zinc, and 1½ parts common salt, are put into a small quantity of water, to form a sort of paste, which is put upon the articles to be colored; these are then placed upon an iron plate over a clear fire, so that they will attain nearly to a black heat, when they are suddenly plunged into cold water. This gives them a beautiful high color. Different hues may be had by a variation in the mixture.

3736. To Electro-gild with Red Gold. Gold having the red color of 14 carat gold may be deposited by the battery in the following manner: Prepare a solution of cyanide of copper by adding cyanide of potassium to a solution of sulphate of copper until the precipitate at first thrown down is redissolved. Add to this a solution of cyanide of gold (*see No.* 3727) in sufficient quantity to give, on trial, the desired color of gold deposit. When using this solution, the positive electrode plate should be of gold of the same color as that desired to be deposited.

3737. Practical Suggestions in Electro-gilding. According to the amount of gold deposited, so will be its durability. A few grains will serve to give a gold color to a very large surface, but it will not last. This proves, however, that the process may be used for the most inferior quality of gilding. Gold thinly laid upon silver will be of a light color, because of the property of gold to transmit light. The solution for gilding silver should be made very hot, but for copper it should be at its minimum heat. A mere blush may be sufficient for articles not subjected to wear; but on watch cases, pencil cases, chains, and the like, a good coating should be given. An ordinary sized watch case should have from 20 grains to a pennyweight; a mere coloring will be sufficient for the inside, but the outside should have as much as possible. A watch case thus gilt, for ordinary wear, will last five or six years without becoming bare. Small silver chains should have 12 grains; pencil cases of ordinary size should have from three to five grains; a thimble from 1 to 2 grains. These suggestions will serve as a guide to amateur gilders, many of whom, having imparted only a color to their pencil cases, feel disappointed upon seeing them speedily become bare; hence arises much of the obloquy thrown upon the process.

3738. To Deposit Copper, Silver, or Gold by the Battery on Paper and other Fibrous Material. The whole question is to make the paper a good conductor of electricity without coating it with a material which may peel off. One of the best methods is to take a solution of nitrate of silver, pour in liquid ammonia till the precipitate at first formed is entirely dissolved again, and place the paper, silk, or muslin for one or two hours in this solution. After taking it out and drying well, it is exposed to a current of hydrogen gas, by which operation the silver is reduced to a metallic state, and the material becomes so good a conductor of electricity that it may be electroplated with copper, silver, or gold, in the usual manner.

3739. To Dissolve Gold from Gilt Articles. Before regilding articles which are partly covered with gold, or when the gilding is imperfect, and the articles require regilding, the gold should be removed from them by putting them into strong nitric acid; and when the articles have been placed in the acid, by adding some common salt, not in solution, but in crystals. By this method gold may be dissolved from any metal, even from iron, without injuring it in the least. After coming out of the acid, the articles must be polished. The best method, however, is to brush off the gold as described for silver (*see No.* 3706), which gives the polish at the same time.

3740. To Recover Gold from its Acid Solution. When the acid has become saturated by the gold that has been dissolved in it, or when it ceases to dissolve the gold rapidly, it is diluted with several times its bulk of water, and then soda or potash added till the greater portion of the acid is neutralized. A solution of sulphate of iron (copperas) is then added, so long as a precipitate is formed; when this settles down it is carefully collected upon a paper filter, washed and dried, and then fused in a crucible with a little borax and common salt, when the gold is found as a button at the bottom of the crucible. When the gold is brushed off, the brushings are burned at a red heat, and the residue fused with carbonate of soda and a little borax; in this case, the gold will not be pure, and will have to be refined.

3741. To Separate Gold from Gilt Copper or Silver. Take a solution of borax in water, apply to the gilt surface, and sprinkle over it some finely powdered sulphur; make the article red hot, and quench it in water; then scrape off the gold, and recover it by means of lead. (*See No.* 3191.)

3742. To Recover Gold from Gilt Articles. Gold may be stripped from articles that have been gilt by placing them in strong nitric acid, in which some salt has been previously dissolved. When a number of articles have been stripped in the solution, it begins to work slowly, and it is time then to abandon it, and use a new one. The gold may then be recovered from the old solution, by evaporating it to dryness, and fusing the residuum with a small piece of soda or potash, the gold being fused into a button. The addition of a little saltpetre will tend to make the refining process more complete. As there is some trouble connected with this process, it is scarcely worth adopting where very small quantities of gold are concerned. In such a case it is a better plan to suspend the article, from which the gold is to be removed, in the gilding bath, in the place of the anode, when gilding another article.

3743. Electro-Gilding Without a Battery. Dissolve 9 parts terchloride of gold in 1000 to 2000 parts pure water; then add 360 parts bicarbonate of potassa, and boil for two hours. The metallic article, if not copper, is covered with a film of copper simultaneously with its being immersed into the boiling gilding liquor, by placing a piece of sheet-copper along with it. As soon as a deposit of copper is observed, the piece of copper is taken out, and the liquor continued boiling until a deep yellow color is obtained. The article is then taken out, washed off with water, and rubbed with a metallic brush. When the liquor has again become clear by settling and decanting, it is again heated to boiling, the article immersed, while the piece of copper is moved about in the fluid without touching the other. The same operation may be renewed *ad libitum*, until the desired thickness of gold is obtained.

3744. Plating and Gilding Without a Battery. Watts gives the following very useful solution of silver or gold for plating or gilding without the aid of a battery: Take 1 ounce nitrate of silver, dissolved in 1 quart distilled or rain water. When thoroughly dissolved, throw in a few crystals of hyposulphite of soda, which will at first form a brown precipitate, but which eventually becomes redissolved if sufficient hyposulphite has been employed. A slight excess of this salt must, however, be added. The solution thus formed may be used for coating small articles of steel, brass, or German silver, by simply dipping a sponge in the solution and rubbing it over the surface of the article to be coated; the silver becomes so firmly attached to the steel (when the solution has been carefully made) that it is removed with considerable difficulty. A solution of gold may be made in the same way, and applied as described. A concentrated solution of either gold or silver, thus made, may be used for coating parts of articles which have stripped or blistered, by applying it with a camel-hair pencil to the part, and touching the spot at the same time with a thin clean strip of zinc.

3745. To Distinguish Gold from its Imitations. The ordinary method of testing gold by the touchstone is founded upon the insolubility of this metal in nitric acid. If a mark be made on the touchstone with the article under examination, the gold is not dissolved by this acid, whereas golden colored alloys of inferior value are dissolved and disappear immediately. When articles are very thinly gilded, the detection of the gold in this manner is uncertain, in which case the following method may be used with advantage. (*See No.* 3190.)

3746. Test Fluid for Gilded Articles. A little carbonate of copper is put into a test-tube, and to this is added, drop by drop, pure hydrochloric acid, till the blue powder has dissolved to a clear green fluid, occasionally warming it over a spirit lamp. This concentrated solution of chloride of copper is diluted for use with from 10 to 11 times its volume of distilled water.

3747. To Test Gilded Articles. Before testing, the metallic surface must be well cleaned. This can be done effectually by brushing it for a minute or two with a little spirits of wine, or, better, with absolute alcohol. The surface having dried, a little of the testing fluid (*see last receipt*) is dropped on and allowed to remain in contact for about a minute. The fluid is then removed by means of a small pipette, and the surface of the metal completely dried with bibulous paper; if no dark spot be then visible, the article is coated with pure gold. If the metallic surface is but lightly gilded, a very slight blackening is sometimes remarked, which may throw a doubt upon the result. In such a case, to make quite certain, a little of the surface may be scraped off, and then the testing fluid again applied. If a dark spot is then perceived, the article may be considered as very thinly gilded.

Electroplating with Various Metals.

The following receipts furnish the means of coating objects with tin, zinc, brass, German silver, and other metals.

3749. To Electroplate Copper, Brass, or German Silver, with Aluminum, take equal measures of sulphuric acid and water, or take 1 measure each sulphuric and hydrochloric acids and 2 measures water; add to the water a small quantity of pipe-clay, in the proportion of 5 or 10 grains by weight to every ounce by measure of water (or ½ ounce to the pint). Rub the clay with the water until the two are perfectly mixed, then add the acid to the clay solution, and boil the mixture in a covered glass vessel 1 hour. Allow the liquid to settle, take the clear, supernatant solution, while hot, and immerse in it an earthen porous cell, containing a mixture of one measure of sulphuric acid and ten measures of water, together with a rod or plate of amalgamated zinc; take a small Smee's battery of 3 or 4 cells, and connect its positive pole by a wire with the piece of zinc in the porous cell. Having perfectly cleaned the surface of the article to be coated, connect it by a wire with the negative pole of the battery, and immerse it in the hot clay solution; immediately abundance of gas will be evolved from the whole of the immersed surface of the article, and in a few minutes, if the size of the article is adapted to the quantity of the current of electricity passing through it, a fine white deposit of aluminum will appear all over the surface. It may then be taken out, washed quickly in clean water, and wiped dry, and polished; but if a thicker coating is required, it must be taken out when the deposit becomes dull in appearance, washed, dried, polished, and reimmersed; and this must be repeated at intervals, as often as it becomes dull, until the required thickness is obtained. With small articles it is not absolutely necessary that a separate battery be employed, as the article to be coated may be connected, as in the one cell method (*see No.* 3669), by a wire with the piece of zinc in the porous cell, and immersed in the outer liquid, when it will receive a deposit, but more slowly than when a battery is employed.

3750. To Electroplate with Tin. Tin is easily deposited from a solution of protochloride of tin. If the two poles or electrodes be kept about 2 inches apart, a most beautiful phenomenon may be observed. The decomposition of the solution is so rapid that it shoots out from the negative electrode like feelers, towards the positive, which it reaches in a few seconds. The space between the poles seems like a mass of crystallized threads, and the electric current passes through them without affecting further decomposition. So tender are these metallic threads that when lifted out of the solution they fall upon the plate like cobweb. Seen through a glass they exhibit a beautiful crystalline structure. Tin may also be deposited from its solution in caustic potash or soda.

3751. Galvanic Tinning. M. Maistrasse-Dupré, it appears, had been commissioned by the French government to apply, by galvanic means, tin upon divers objects which had been made of so-called galvanized iron—that is, iron covered with zinc. To this purpose he applied galvanic elements made of copper and zinc plates, the length of which is 48 inches, the width 28 inches, placed in a leaden trough and separated and isolated by means of wooden partitions. The copper sheet was immersed in a mixture of equal parts of acetate of lead and common salt, and the zinc element was placed in weak sulphuric acid, specific gravity 1.060. This battery remains in constant action and working order for 8 days, at an outlay of only 2 francs. When the objects which are galvanically tinned are afterwards heated to the melting point of tin, the goodness and durability of hot-tinned materials is thus obtained. Copper thus tinned (galvanically), and afterwards heated, is superficially converted into bell metal, while the method of tinning galvanically has the great advantage over the old method, that it can be applied to objects to which the method of tinning in ordinary use is not applicable.

3752. To Electroplate with Brass. Brass can be deposited when the solution is composed of 1 part sulphate of copper in 4 parts hot water, 8 parts sulphate of zinc in 16 parts of hot water, 18 parts cyanide of potassium in 36 parts of hot water. These are mixed, and 250 parts of water added. Instead of a copper positive electrode plate, one of brass is necessary; the solution is required to be kept nearly boiling, and a powerful battery to be used.

3753. To Prepare Cyanides of Copper and Zinc. For copper, dissolve 1 ounce of sulphate of copper in 1 pint of hot water. For zinc, dissolve 1 ounce of the sulphate of zinc in 1 pint of hot water, and proceed the same as for cyanide of silver. (*See No.* 3697.)

3754. Cyanide Solution of Copper or Zinc. Dissolve 8 ounces (troy) cyanide of potassium, and 3 ounces cyanide of copper or zinc in 1 gallon of rain or distilled water. They should be used at about 160° Fahr.; with a compound battery of 3 to 12 cells.

3755. Cyanide Solution of Copper. To prepare copper solutions by means of cyanide of potassium, for covering iron and other positive metals, there are several methods, but the method adopted in manufacturing purposes is as follows: To a solution of sulphate of copper, add a solution of ferrocyanide of potassium (yellow prussiate of potassa), so long as a precipitate continues to be formed; this is allowed to settle, and, the clear liquor being decanted, the vessel is filled with water, and when the precipitate settles, the liquor is again decanted, and these washings are repeated until the sulphate of potash is washed quite out. This is known by adding a little chloride of barium to a small quantity of the washings; if no white precipitate is formed by this test, the precipitate is sufficiently washed. A solution of cyanide of potassium is now added to this precipitate until it is dissolved, during which process the solution becomes warm by the chemical reaction that takes place. The solution is filtered, and allowed to repose all night. If the solution of cyanide of potassium that is used is strong, the greater portion of the ferrocyanide of potassium crystallizes in the solution, and may be collected and preserved for use again. If the solution of cyanide of potassium used to dissolve the precipitate is dilute, it will be necessary to condense the liquor by evaporation, to obtain the yellow prussiate in crystals; the remaining solution is the coppering solution. Should it not be convenient to separate the yellow prussiate by crystallization, the presence of that salt in the solution does not interfere with its power of depositing copper.

3756. To Prepare Iron for Coating with Copper. When it is required to cover an iron article with copper, it is first steeped in hot caustic potash or soda, to remove any grease or oil. Being washed from that, it is placed for a short time in dilute sulphuric acid, consisting of about 1 part of acid to 16 parts water, which removes any oxide that may exist. It is then washed in water, and scoured with sand till the surface is perfectly clean, and finally attached to the battery, and immersed in the cyanide solution. (*See No.* 3755.) All this must be done with dispatch, so as to prevent the iron combining with oxygen. An immersion of five minutes' duration in the cyanide solution is sufficient to deposit upon the iron a film of copper. But it is necessary to the complete protection of the iron, that it should have a tolerably thick coating; and, as the cyanide process is expensive, it is preferable, when the iron has received a film of copper by the cyanide solution, to take it out, wash it in water, and attach it to a single cell or weak battery, and put it into a solution of sulphate of copper. If there is any part not sufficiently covered with copper by the cyanide solution, the sulphate will make these parts of a dark color, which a touch of the finger will remove. When such is the case, the article must be taken out, scoured, and put again into the cyanide solution till perfectly covered. A little practice will render this very easy. The sulphate solution, when used for covering iron, should be prepared by adding to it by degrees a little caustic soda, so long as the precipitate formed is redissolved. This neutralizes a great portion of the sulphuric acid, and thus the iron is not so readily acted upon.

3757. To Coat Iron with Zinc. In covering iron with zinc, the precautions necessary for copper are not required; zinc being the positive metal, acids have a stronger affinity for it than for iron, and therefore an acid solution may be used. The solution generally used is the sulphate, used in the same way as sulphate of copper. (*See No.* 3661.)

3758. Test for Galvanized Iron. When zinc is deposited on iron by galvanic agency, it should form a chemical combination with the iron, and not be merely attached thereto. It is proposed by Mr. T. Bruce Warren, of England, to use this fact for practically testing the efficiency of the galvanization. If mercury be poured over the surface, the zinc that is only locally attached will form an amalgam with the mercury. Mr. Warren also uses this as a quantitative test, to verify the amount of zinc in combination with the iron.

3759. To Make a Cyanide Solution of Brass. Dissolve 1 pound (troy) cyanide of potassium, 2 ounces cyanide of copper, and 1 ounce cyanide of zinc, in 1 gallon rain or distilled water; then add 2 ounces muriate of ammonia. This solution is to be used at 160° Fahr. on smooth work, with a compound battery of 3 to 12 cells.

3760. Electroplating with Platinum. This metal has never yet been successfully deposited as a protecting coating to other metals. A solution may be made by dissolving it in a mixture of nitric and muriatic acids, the same as is employed in dissolving gold; but heat must be applied. The solution is then evaporated to dryness, and to the remaining mass is added a solution of cyanide of potassium; next, it must be slightly heated for a short time, and then filtered. This solution, evaporated, yields beautiful crystals of cyanide of platinum and potassium; but it is unnecessary to crystallize the salt. A very weak battery power is required to deposit the metal; the solution should be heated to 100°. Great care must be taken to obtain a fine metallic deposit; indeed, the operator may not succeed once in twenty times in getting more than a mere coloring of metal over the surface, and that not very adhesive. The causes of the difficulty are probably these: the platinum used as an electrode is not acted upon; the quantity of salt in solution is very little; it requires a particular battery strength to give a good deposit, and the slightest strength beyond this gives a black deposit; so that, were the proper relations obtained, whenever there is any deposit, the relations of battery and solution are changed, and the black pulverulent deposit follows.

3761. Electroplating with Palladium. Palladium is a metal very easily deposited. The solution is prepared by dissolving the metal in nitro-muriatic acid, and evaporating the solution nearly to dryness; then adding cyanide of potassium till the whole is dissolved; the solution is then filtered and ready for use. The cyanide of potassium holds a large quantity of this metal in solution, and the electrode is acted upon while the deposit is proceeding. Articles covered with this metal assume the appearance of the metal; but so far as we are aware, it has not yet been applied to any practical purpose. It requires rather a thick deposit to protect metals from the action of acids, which is, probably, the only use it can be applied to.

3762. Electroplating with Nickel. Nickel is very easily deposited, and may be prepared for this purpose by dissolving it in nitric acid, then adding cyanide of potassium to precipitate the metal; after which the precipitate is washed and dissolved by the addition of more cyanide of potassium. Or the nitrate solution may be precipitated by carbonate of potash; this should be well washed, and then dissolved in cyanide of potassium; a proportion of carbonate of potash will be in the solution, which has not been found to be detrimental. The metal is very easily deposited; it yields a color approaching to silver, which is not liable to tarnish on exposure to the air. A coating of this metal would be very useful for covering common work, such as gasaliers, and other gas-fittings, and even common plate. The great difficulty experienced is to obtain a positive electrode: the metal is very difficult to fuse, and so brittle that we have never been able to obtain either a plate or a sheet of it. Could this difficulty be easily overcome, the application of nickel to the coating of other metals would be extensive, and the property of not being liable to tarnish would make it eminently useful for all general purposes.

3763. Nagel's Method of Electroplating with Nickel. A process devised by Mr. Nagel, of Hamburg, for coating iron, steel, and other oxidizable metals with an electro deposit of nickel or cobalt, consists in taking 4 parts, by weight, of pure sulphate of the protoxide of nickel by crystallization, and 2 parts, by weight, of pure ammonia, so as to form a double salt, which is then dissolved in 60 parts of distilled water, and 12 parts of ammoniacal solution of the specific gravity of .909 added. The electro deposit is effected by an ordinary galvanic current, using a platinum positive pole, the solution being heated to about 100° Fahr. The strength of the galvanic current is regulated according to the number of objects to be coated.

3764. To Protect Steel from Rusting. It has been found by experiment that an electro-deposited coating of nickel protects the surface of polished steel completely from rust. Swords, knives, and other articles of steel liable to exposure, may be coated with nickel without materially altering the color of the metal.

3765. To Protect Copper and Brass. Copper and brass are equally well protected by nickel (*see No.* 3764), but, of course, with change of color on the surface. The nickel facing, when burnished, has a whiter color than polished steel, but not as white as silver, being nearer in appearance to platinum.

3766. Nagel's Method of Electroplating Metal with Cobalt. For coating with cobalt, 138 parts, by weight, of pure sulphate of cobalt, are combined with 69 parts of pure ammonia, to form a double salt, which is then dissolved in 1000 parts of distilled water, and 120 parts of ammoniacal solution, of the same specific gravity as before, are added. The process of deposition with cobalt is the same as with nickel. (*See No.* 3763.)

3767. To Electroplate with Silicium. In the following manner, a coating of silicium can be obtained direct from silica: Take the following proportions: ¾ ounce, by measure, of hydrofluoric acid, ¼ ounce hydrochloric acid, and 40 or 50 grains either of precipitated silica, or of fine white sand (the former dissolves most freely), and boil the whole together for a few minutes, until no more silica is dissolved. Use this solution exactly in the same manner as the clay solution (*see No.* 3767), and a fine white deposit of metallic silicium will be obtained, provided that the size of the article is adapted to the quantity of the electric current. Common red sand, or, indeed, any kind of silicious stone, finely powdered, may be used in place of the white sand, and with equal success, if it be previously boiled in hydrochloric acid, to remove the red oxide of iron or other impurities. In depositing both aluminum and silicium, it is necessary to well saturate the acid with the solid ingredients by boiling, otherwise very little deposit of metal will be obtained.

3768. To Prepare a Brass Solution. For each gallon of water used to make the solution, take 1 pound carbonate of ammonia, 1 pound cyanide of potassium, 2 ounces cyanide of copper, and 1 ounce cyanide of zinc. This constitutes the solution for the decomposing cell. It may be prepared, also, from the above proportions of carbonate of ammonia and cyanide of potassium, by immersing in it a large sheet of brass of the desired quality, and making it the anode or positive electrode of a powerful galvanic battery or magneto-electric machine; and making a small piece of metal the cathode or negative electrode, from which hydrogen must be freely evolved. This operation is continued till the solution has taken up a sufficient quantity of the brass to produce a reguline deposit.

3769. To Electroplate with Brass. The solution (*see No.* 3768) may be used cold; but it is desirable, in many cases, to heat it (according to the nature of the articles to be deposited upon) to 212° Fahr. For wrought or fancy work, about 150° Fahr. will give excellent results. The galvanic battery, or magneto-electric machine, must be capable of evolving hydrogen freely from the cathode or negative electrode, or article attached thereto. It is preferred to have a large anode or positive electrode, as this favors the evolution of hydrogen. The article or articles treated as before described will immediately become coated with brass. By continuing the process, any desired thickness may be obtained. Should the copper have a tendency to come down in a greater proportion than is desired, which may be known by the deposit assuming too red an appearance, it is corrected by the addition of carbonate of ammonia, or by a reduction of temperature, when the solution is heated. Should the zinc have a tendency to come down in too great a proportion, which may be seen by the deposit being too pale in its appearance, this is corrected by the addition of cyanide of potassium or by an increase of temperature.

3770. To Electroplate with German Silver. The alloy, German silver, is deposited by means of a solution consisting of carbonate of ammonia and cyanide of potassium (in the proportions given above for the brass), and cyanides or other compounds of nickel, copper, and zinc, in the requisite proportions to constitute German silver. It is, however, preferred to make the solution by means of the galvanic battery or magneto-electric machine, as above described for brass. Should the copper of the German silver come down in too great a proportion, this is corrected by adding carbonate of ammonia, which brings down the zinc more freely; and should it be necessary to bring down the copper in greater quantity, cyanide of potassium is added—such treatment being similar to that of the brass before described.

Bronzing.

This is the process of giving a bronze-like or an antique metallic appearance to the surface of copper, brass, and other metals. This is generally effected by the action of some substance which combines with and changes the nature of the surface of the metal. The application of powdered bronzing substances, made to adhere by sizing, &c., to the surface of other material than metal, such as wood, plaster, &c., is termed surface bronzing. (*See Nos.* 3382, *&c.*)

3772. Brown Bronzes for Medals, &c. Take a wine-glass of water, and add to it 4 or 5 drops nitric acid; with this solution wet the medal (which ought to have been previously well cleaned from oil or grease) and then allow it to dry; when dry impart to it a gradual and equable heat, by which the surface will be darkened in proportion to the heat applied.

3773. Bronzing with Crocus. Make a thin paste of crocus and water; lay this paste on the face of the medal, which must then be put into an oven, or laid on an iron plate over a slow fire; when the paste is perfectly reduced to powder, brush it off and lay on another coating; at the same time quicken the fire, taking care that the additional heat is uniform; as soon as the second application of paste is thoroughly dried, brush it off. The medal being now effectually secured from grease, which often occasions failures in bronzing, coat it a third time, but add to the strength of the fire, and sustain the heat for a considerable time; a little experience will soon enable the operator to decide when the medal may be withdrawn; the third coating being removed, the surface will present a beautiful brown bronze. If the bronze is deemed too light the process can be repeated.

3774. Bronzing with Black-Lead. After the medal has been well cleaned from wax or grease, by washing it in a little caustic alkali, brush some black-lead over the face of it, and then heat it in the same way as described in No. 3773 for crocus; or a thin paste of black-lead may be used, and the processes already referred to be repeated until the desired brown tint is obtained. In this kind of bronze a little hematitic iron ore, which has an unctuous feel, may be brushed over the face of the bronze, by which a beautiful lustre is imparted to it, and a considerable variety in the shade may be obtained. In the brown bronzes the copper is slightly oxidized on the surface.

3775. Plumbago Bronze. This bronze is obtained by brushing the surface of the medal with plumbago, then placing it on a clear fire till it is made too hot to be touched, and applying a plate brush so soon as it ceases to be hot enough to burn the brush. A few strokes of the brush will produce a dark brown polish, approaching black, but entirely distinct from the well known appearance of black-lead. If the same operation is performed on a medal that has been kept some days, or upon one that has been polished, a different, but very brilliant tint is produced. The color is between red and brown. The richness of color thus produced is by many preferred to the true dark brown.

3776. Chinese Bronze. Take 2 ounces each verdigris and vermilion; 5 ounces each alum and sal-ammoniac, all in fine powder, and sufficient vinegar to make a paste; then spread it over the surface of the copper, previously well cleaned and brightened; uniformly warm the article by the fire, and afterwards well wash and dry it, when, if the tint be not deep enough, the process may be repeated. The addition of a little sulphate of copper inclines the color to a chestnut brown; and a little borax to a yellowish brown. Much employed by the Chinese for copper tea-urns.

3777. Carbonate of Iron Bronze. Beautiful tints are produced by using plate-powder or rouge. After moistening with water, it is applied and treated in precisely the same manner as the plumbago. (*See No.* 3775.)

3778. Black Bronzes. A very dark colored bronze may be obtained by using a little sulphuretted alkali (sulphuret of ammonia is best). The face of the medal is washed over with the solution, which should be dilute, and the medal dried at a gentle heat, and afterwards polished with a hard hair brush. Sulphuretted hydrogen gas is sometimes employed to give this black bronze, but the effect of it is not so good, and the gas is very deleterious when breathed. In these bronzes the surface of the copper is converted into a sulphuret.

3779. German Method of Bronzing Brass Black. There are two methods of procuring a black lacquer upon the surface of brass. The one which is that usually employed for optical and scientific instruments, consists in first polishing the object with Tripoli, then washing it with a mixture composed of 1 part nitrate of tin and 2 parts chloride of gold, and, after allowing this wash to remain on for about 12 or 15 minutes, wiping it off with a linen cloth. An excess of acid increases the intensity of the tint. In the other method, copper turnings are dissolved in nitric acid until the acid is saturated; the objects are immersed in the solution, cleaned, and subsequently heated moderately over a charcoal fire. This process must be repeated in order to produce a black color, as the first trial only gives a deep green; when the desired color is attained, the finishing touch is given by polishing with olive oil.

3780. Black Bronzes. Many metallic solutions, such as weak acid solutions of platinum, gold, palladium, antimony, etc., will impart a dark color to the surface of medals when they are dipped into them. The medal, after being dipped into the metallic solution, is to be well washed and brushed. In such bronzes the metals contained in the solution are precipitated upon the face of the copper medal, which effect is accompanied by a partial solution of the copper.

3781. Green Bronzes for Figures and Busts. Green bronzes require a little more time than those already described. They depend upon the formation of an acetate, carbonate, or other green salt of copper upon the surface of the medal. Steeping for some days in a strong solution of common salt will give a partial bronzing which is very beautiful, and, if washed in water and allowed to dry slowly, is very permanent. Sal ammoniac may be substituted for common salt. Even a strong solution of sugar, alone, or with a little acetic or oxalic acid, will produce a green bronze; so also will exposure to the fumes of dilute acetic acid, to weak fumes of hydrochloric acid, and to several other vapors. A dilute solution of ammonia allowed to dry upon the copper surface will leave a green tint, but not very permanent.

3782. Bronzing with Bleaching Powder. Electrotypes may be bronzed green, having the appearance of ancient bronze, by a very simple process. Take a small portion of bleaching powder (chloride of lime), place it in the bottom of a dry vessel, and suspend the medal over it, and cover the vessel; in a short time the medal will acquire a green coating, the depth of which may be regulated by the quantity of bleaching powder used, or the time that the medal is suspended in its fumes; of course, any sort of vessel, or any means by which the electrotype may be exposed to the fumes of the powder, will answer the purpose; a few grains of the powder is all that is required. According as the medal is clean or tarnished, dry or wet, when suspended, different tints, with different degrees of adhesion, will be obtained.

3783. Fine Green Bronze. Dissolve 2 ounces verdigris and 1 ounce sal-ammoniac in 1 pint vinegar, and dilute the mixture with water until it tastes but slightly metallic, when it must be boiled for a few minutes, and filtered for use. Copper medals, &c., previously thoroughly cleaned from grease and dirt, are to be steeped in the liquor at the boiling point, until the desired effect is produced. Care must be taken not to keep them in the solution too long. When taken out, they should be carefully washed in hot water, and well dried. Gives an antique appearance.

3784. To Bronze Brass Orange, Greenish Grey and Violet Tint. An orange tint, inclining to gold, is produced by first polishing the brass, and then plunging it for a few seconds into a neutral solution of crystallized acetate of copper, care being taken that the solution is completely destitute of all free acid, and possesses a warm temperature. Dipped into a bath of copper, the resulting tint is a greyish green, while a beautiful violet is obtained by immersing it for a single instant in a solution of chloride of antimony, and rubbing it with a stick covered with cotton. The temperature of the brass at the time the operation is in progress has a great influence upon the beauty and delicacy of the tint; in the last instance it should be heated to a degree so as just to be tolerable to the touch.

3785. Moire Bronze. A moire appearance, vastly superior to that usually seen, is produced by boiling the object in a solution of sulphate of copper. According to the proportions observed between the zinc and the copper in the composition of the brass article, so will the tints obtained vary. In many instances it requires the employment of a slight degree of friction with a resinous or waxy varnish, to bring out the wavy appearance characteristic of moire, which is also singularly enhanced by dropping a few iron nails into the bath.

3786. French Bronze. An eminent Parisian sculptor makes use of a mixture of ½ ounce sal-ammoniac, ½ ounce common salt, 1 ounce spirits of hartshorn, and 1 imperial quart of vinegar. A good result will also be obtained by substituting an additional ½ ounce sal-ammoniac, instead of the spirits of hartshorn. The piece of metal, being well cleaned, is to be rubbed with one of these solutions, and then dried by friction with a clean brush. If the hue be found too pale at the end of 2 or 3 days, the operation may be repeated. It is found to be more advantageous to operate in the sunshine than in the shade.

3787. To Bronze Copper with Sulphur. When objects made of copper are immersed in melted sulphur mixed with lampblack, the objects so treated obtain the appearance of bronze, and can be polished without losing that aspect.

3788. Antique Bronze. Dissolve 1 ounce sal-ammoniac, 3 ounces cream of tartar, and 6 ounces common salt, in 1 pint hot water; then add 2 ounces nitrate of copper, dissolved in ½ pint water; mix well, and apply it repeatedly to the article, placed in a damp situation, by means of a brush moistened therewith. This produces a very antique effect.

3789. Antique Bronze. Rub the medal with a solution of sulphuret of potassium, then dry. This produces the appearance of antique bronze very exactly.

3790. Bronzing Liquids for Tin Castings. Wash them over, after being well cleaned and wiped, with a solution of 1 part sulphate of iron, and 1 part sulphate of copper, in 20 parts water; afterwards with a solution of 4 parts verdigris in 11 of distilled vinegar; leave for an hour to dry, and then polish with a soft brush and crocus.

3791. To Bronze Iron Castings. Iron castings may be bronzed by thorough cleaning (*see No.* 3641) and subsequent immersion in a solution of sulphate of copper, when they acquire a coat of the latter metal. They must be then washed in water.

3792. Surface Bronzing. This term is applied to the process of imparting to the surfaces of figures of wood, plaster of Paris, &c., a metallic appearance. This is done by first giving them a coat of oil or size varnish, and when this is nearly dry, applying with a dabber of cotton or a camel-hair pencil, any of the metallic bronze powders; or the powder may be placed in a little bag of muslin, and dusted over the surface, and afterwards finished off with a wad of linen. The surface must be afterwards varnished.

3793. To Bronze Paper. Paper is bronzed by mixing the powders up with a little gum and water, and afterwards burnishing. The paper used should contain sufficient sizing not to absorb the gum.

3794. Beautiful Red Bronze Powder. Mix together sulphate of copper, 100 parts; carbonate of soda, 60 parts; apply heat until they unite into a mass, then cool, powder, and add copper filings, 15 parts; well mix, and keep them at a white heat for 20 minutes, then cool, powder, wash thoroughly with water, and dry.

3795. Gold Colored Bronze Powder. Verdigris, 8 ounces; tutty powder, 4 ounces; borax and nitre, each 2 ounces; bichloride of mercury, ½ ounce; make them into a paste with oil, and fuse them together. Used in japanning as a gold color. Or: Grind Dutch foil or pure gold leaf to an impalpable powder. (*See Nos.* 2491 *and* 2517.)

3796. Silver White Bronze Powder. Melt together 1 ounce each bismuth and tin, then add 1 ounce running quicksilver; cool and powder.

3797. Graham's Quick Bronzing Liquids. The following 19 receipts are preparations for bronzing brass, copper, and zinc, by simple immersion. Their action is immediate.

3798. Black or Brown Bronzing for Brass, Copper, or Zinc. Dissolve 5 drachms nitrate of iron in 1 pint water. Or: 5 drachms perchloride of iron in 1 pint water. A black may also be obtained from 10 ounces muriate of arsenic in 2 pints permuriate of iron, and 1 pint water.

3799. Brown or Red Bronzing for Brass. Dissolve 16 drachms nitrate of iron, and 16 drachms hyposulphite of soda, in 1 pint water. Or: 1 drachm nitric acid may be substituted for the nitrate of iron.

3800. Red-Brown Bronzing for Brass. Dissolve 1 ounce nitrate of copper, and 1 ounce oxalic acid, in 1 pint water, brought to the boil, and then cooled. Or: 1 pint solution of ferrocyanide of potassium and 3 drachms nitric acid. This latter is slow in action, taking an hour to produce good results.

3801. Dark Brown Bronzing for Brass. Mix 1 ounce cyanide of potassium, and 4 drachms nitric acid, with 1 pint water.

3802. Red Bronzing for Brass. Mix 30 grains tersulphite of arsenic, 6 drachms solution of pearlash, and 1 pint water.

3803. Orange Bronzing for Brass. Mix 1 drachm potash solution of sulphur with 1 pint water.

3804. Olive Green Bronzing for Brass. Dissolve 1 pint permuriate of iron in 2 pints water.

3805. Slate-Colored Bronzing for Brass. Dissolve 2 drachms sulphocyanide of potassium, and 5 drachms perchloride of iron, in 1 pint water.

3806. Blue Bronzing for Brass. Mix 20 drachms hyposulphite of soda with 1 pint water.

3807. Steel-Grey Bronzing for Brass, or Copper. Mix 1 ounce muriate of arsenic with 1 pint water, and use at a heat not less than 180° Fahr.

3808. Dark Drab Bronzing for Copper. This is prepared by adding 2 drachms sulphocyanide of potassium to the mixture given in No. 3807. Or: mix 1 ounce sulphate of copper, 1 ounce hyposulphite of soda, 2 drachms hydrochloric acid, and 1 pint water.

3809. Bright Red Bronzing for Copper. Mix 2 drachms sulphide of antimony, and 1 ounce pearlash, in 1 pint water.

3810. Dark Red Bronzing for Copper. Dissolve 1 drachm sulphur, and 1 ounce pearlash, in 1 pint water.

3811. Dark Grey Bronzing for Zinc. Mix 1 drachm protochloride of tin, and 1 drachm sulphocyanide of potassium, with 1 pint water. Or: Dissolve 1 drachm each sulphate of copper and muriate of iron, in 2 pints water. A similar effect may be obtained by mixing muriate of lead with water to the consistency of cream.

3812. Green-Grey Bronzing for Zinc. Dissolve ¼ drachm muriate of iron in 1 pint water.

3813. Red Bronzing for Zinc. Use garancine (madder-red) infusion boiling hot.

3814. Copper-Colored Bronzing for Zinc. Agitate the articles in a solution of 8 drachms sulphate of copper, and 8 drachms hyposulphite of soda, in 1 pint water.

3815. Copper-Colored Bronzing for Zinc Plates. Make a solution of 4 drachms sulphate of copper, and 4 drachms pearlash, in 1 pint water. Immerse the zinc plate in it, connected at one end with a plate of copper, as represented in Fig. 1, No. 3665. This, it will be seen, induces a galvanic current, and is electroplating on a small scale.

3816. Purple Bronzing for Zinc. Immerse in a boiling infusion of logwood.

3817. Larkin's Bronzing Fluids for Alloys of a Silvery-Grey Color. Mr. Larkin states that, for the purpose of rendering alloys which are of a silvery-grey color, perfectly suitable as substitutes for copper, bronze, brass, and other metals, the color proper to the metals which they are intended to substitute is imparted to them by means of any solution of copper. The hydrochlorate of copper is found to answer best, and is employed as directed in the five following receipts.

3818. Directions for Using Larkin's Bronzing Fluids. In either of these methods of coloring, a solution of sal-ammoniac may be substituted for the liquid ammonia. The quantities of each ingredient have not been stated, as these depend upon the nature of the alloy, the shade or hue desired, and the durability required. The bluish-bronze color may be superadded to the red or copper color, whereby a beautiful light color is produced on the prominent parts of the article bronzed, or on the parts from which the blackish-bronze color may have been rubbed off. These new alloys may be used as substitutes for various metals now in general use, such as iron, lead, tin, or copper, in pipes and tubes; and bronze, brass, and copper, in machinery and manufactories, as well as for most of the other purposes for which more expensive metals are employed.

3819. Blackish Bronze Coloring. For giving silvery-grey alloys a blackish-bronze color, they are treated with a solution of hydrochlorate of copper diluted with a considerable quantity of water, and a small quantity of nitric acid may be added.

3820. Lead or Copper Coloring. To impart a lead or copper color, add to the solution of hydrochlorate of copper, liquid ammonia and a little acetic acid.

3821. Antique Bronze Coloring. To impart a brass or antique bronze color, either of the three following means may be adopted:—A solution of copper, with some acetic acid. Or:—The means before described for copper color, with a large proportion of liquid ammonia. Or:—Water acidulated with nitric acid, by which beautiful bluish shades may be produced. It must be observed, however, this last process can only be properly employed on the alloys which contain a portion of copper.

3822. Drab Bronze for Brass. Brass obtains a very beautiful drab bronze by being worked in moulders' damp sand for a short time and brushed up.

3823. To Make Bronze Powder for Plaster Casts, &c. To a solution of soda-soap in linseed oil, cleared by straining, add a mixture of 4 pints sulphate of copper solution, and 1 pint sulphate of iron solution, which precipitates a metallic soap of a peculiar bronze hue; wash with cold water, strain, and dry to powder.

3824. To Bronze Plaster Casts, &c. The powdered soap of the last receipt is thus applied: Boil 3 pounds pure linseed oil with 12 ounces finely powdered litharge; strain through a coarse canvas cloth, and allow to stand until clear; 15 ounces of this soap varnish, mixed with 12 ounces metallic soap powder (*see last receipt*), and 5 ounces fine white wax, are to be melted together at a gentle heat in a porcelain basin, by means of a water-bath, and allowed to remain for a time in a melted state to expel any moisture that it may contain; it is then applied with a brush to the surface of the plaster previously heated to 200° Fahr., being careful to lay it on smoothly, and without filling up any small indentations of the plaster design. Place it for a few days in a cool place; and, as soon as the smell of the soap varnish has gone off, rub the surface over with cotton wool, or fine linen rag, and variegated with a few streaks of metal powder or shell gold. Small objects may be dipped in the melted mixture, and exposed to the heat of a fire till thoroughly penetrated and evenly coated with it.

3825. To Make Bronzing for Wood. Grind separately to a fine powder, Prussian blue, chrome yellow, raw umber, lampblack, and clay, and mix in such proportions as will produce a desired dark green hue; then mix with moderately strong glue *size*.

3826. To Bronze Wood. First coat the clean wood with a mixture of size and lampblack; then apply two coats of the green colored sizing in the last receipt; and lastly with bronze powder, such as powdered Dutch foil, mosaic gold, &c., laid on with a brush. Finish with a thin solution of Castile soap; and, when dry, rub with a soft woolen cloth.

3827. To Bronze Porcelain, Stoneware, and Composition Picture Frames. A bronzing process, applicable to porcelain, stoneware, and composition picture and looking-glass frames is performed as follows: The articles are first done over with a thin solution of water-glass (*see No.* 2816) by the aid of a soft brush. Bronze powder is then dusted on, and any excess not adherent is knocked off by a few gentle taps. The article is next heated, to dry the silicate, and the bronze becomes firmly attached. Probably, in the case of porcelain, biscuit, or stoneware, some chemical union of the silicate will take place, but in other cases the water-glass will only tend to make the bronze powder adhere to the surface. After the heating, the bronze may be polished or burnished with agate tools.

3828. Browning for Gun Barrels. Mix 1 ounce each aqua-fortis and sweet spirits of nitre; 4 ounces powdered blue vitriol; 2 ounces tincture of iron, and water, 1½ pints; agitate until dissolved.

Or: Blue vitriol and sweet spirits of nitre, of each 1 ounce; water, 1 pint; dissolve as last.

Or: Mix equal parts of butter of antimony and sweet oil, and apply the mixture to the iron previously warmed.

3829. To Brown Gun Barrels. The gun barrel to be browned must be first polished and then rubbed with whiting to remove all oily matter. Its two ends should be stopped with wooden rods, which serve as handles, and the touch-hole filled with wax. Then rub on the solution (*see last receipt*) with a linen rag or sponge till the whole surface is equally moistened. Let it remain till the next day, then rub it off with a stiff brush. The liquid may be again applied until a proper color is produced. When this is the case, wash in pearlash water, and afterwards in clean water, and then polish, either with the burnisher or with bees' wax; or apply a coat of shellac varnish. (*See No.* 2954.)

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bolt or pivot of the front pair. To the under side of the bottom board and four inches from the end screw two strips 1" × 2" × 6", with a groove cut to receive the axle. Extending beyond these strips fasten two brake-straps, 1" × 2" × 8", each provided with a groove ½" by 2" by 4" to admit the brakes (see 4 in Figs. A and D). Two and 4 in the Figs. A and D may be made in one piece; but remember that the measurements here given are for 14" wheels, so that a change in the length of the strap and the location of the groove would have to be made if your wheels were of a different size. lamps are to be bolted in place in a similar way. Use cans with slip tops that may be replaced after the bolting has been done. Measurements for the seat can be taken from the diagram. The rounding top is made of a cheese box with the front cut and straightened out, and the sides tapered. Two sorts of brakes are possible, but the foot-brake is to be preferred. Paint the car red, and don't forget the tail-number. If you wish, you can fix your dark-lantern within the search-light can. When "off," the brake should rest one inch from the wheels.

The hood is made of a box 15" × 12" × 10". The boards are to be removed carefully and replaced when the box-ends have been shaped as seen in Fig. B. Before putting the last board on again reach in and bolt the search-light on. The search-light is a 2 qt. can. Through it and through the pivot block (2" × 2" × 2") and the top board of the hood bore a hole for the bolt, which should be set just tight enough to allow the light to turn. The side

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